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Title:

THE HUMAN E3 α UBIQUITIN LIGASE FAMILY

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(Richard Zimmermann)

THE HUMAN E3 α UBIQUITIN LIGASE FAMILY

RELATED APPLICATIONS

5 This application claims priority under 35 U.S.C. § 119 from U.S. provisional patent application Serial No. 60/187,911 filed March 8, 2000.

FIELD OF THE INVENTION

10 The present invention includes novel human E3 α ubiquitin ligase polypeptides (huE3 α I and huE3 α II) and nucleic acid molecules encoding the same. The invention also relates to vectors, host cells, selective binding agents, such as antibodies, and methods for producing huE3 α polypeptides. Also provided for are methods for the diagnosis, treatment, amelioration and/or prevention of diseases associated with huE3 α polypeptides, as well as methods for identifying modulators of huE3 α ligase activity.

15 BACKGROUND OF THE INVENTION

Technical advances in the identification, cloning, expression and manipulation of nucleic acid molecules and deciphering of the human genome have greatly accelerated the discovery of novel therapeutics based upon deciphering of the human genome. Rapid nucleic acid sequencing techniques can now generate sequence
20 information at unprecedented rates and, coupled with computational analyses, allow the assembly of overlapping sequences into the partial and entire genomes as well as the identification of polypeptide-encoding regions. A comparison of a predicted amino acid sequence against a database compilation of known amino acid sequences can allow one to determine the extent of homology to previously identified sequences and/or structural
25 landmarks. The cloning and expression of a polypeptide-encoding region of a nucleic acid molecule provides a polypeptide product for structural and functional analyses. The manipulation of nucleic acid molecules and encoded polypeptides to create variants and derivatives thereof may confer advantageous properties on a product for use as a therapeutic.

30 In spite of significant technical advances in genome research over the past decade, the potential for the development of novel therapeutics based on the human genome is still largely unrealized. Many genes encoding potentially beneficial

polypeptide therapeutics, or those encoding polypeptides which may act as "targets" for therapeutic molecules, have still not been identified. In addition, structural and functional analyses of polypeptide products from many human genes have not been undertaken.

5 Accordingly, it is an object of the invention to identify novel polypeptides and nucleic acid molecules encoding the same which have diagnostic or therapeutic benefit.

10 Most types of intracellular proteins are degraded through the ubiquitin-proteasome pathway. In this system, proteins are marked for proteasomal degradation by the conjugation of ubiquitin molecules to the protein. Conjugation of the ubiquitin molecule initially involves activation by the E1 enzyme. Upon activation the ubiquitin molecule is transferred to the E2 enzyme which serves as a carrier-protein. The E2 enzyme interacts with a specific E3 ligase family member. The E3 ligase binds to proteins targeted for degradation and catalyzes the transfer of ubiquitin from the E2
15 carrier enzyme to the target protein. Since the target protein binds to the ligase prior to conjugation, E3 ligase is the rate limiting step for ubiquitin conjugation and determines the specificity of the system. The ubiquitin chain serves as a degradation marker for the 26S proteasome (See Ciechanover, *EMBO J.*, 17: 7151-7160, 1998).

20 There are only a few known E3 ligases and the sequence homology between them is low. The E3 α family is the main family of intracellular ubiquitin ligases and is involved in N-end rule pathway of protein degradation. The N-end rule states that there is a strong relation between the *in vivo* half-life of a protein and the identity of its N-terminal amino acids. Accordingly, E3 α enzyme binds directly to the primary destabilizing N-terminal amino acid and catalyzes ubiquitin conjugation thereby
25 targeting the protein for degradation. E3 α family members also recognize non-N-end rule substrates (See Ciechanover, *EMBO J.*, 17: 7151-7160, 1998).

30 The E3 α enzyme family currently consists of intracellular enzymes isolated from rabbit (Reiss and Hershiko, *J. Biol. Chem.* 265: 3685-3690, 1990), mouse (Kwon *et al.*, *Proc. Natl. Acad. Sci., U.S.A* 95: 7898-7903, 1999), yeast (Bartel *et al.*, *EMBO J.*, 9: 3179-3189, 1990) and the *C. elegans* (Wilson *et al.*, *Nature*, 368: 32-38, 1994; Genbank Accession No. U88308) counterparts termed UBR-1. Comparison of these known sequences indicates regions of high similarity regions (I-V) which suggest

the existence of a distinct family. The regions of similarity contain essential residues for the recognition of N-end rule substrates. In region I, the residues Cys-145, Val-146, Gly-173, and Asp-176 are known to be necessary for type-1 substrate binding in yeast and are conserved in the mouse. In regions II and III, residues Asp-318, His-321, and Glu-560 are essential for type-2 substrate binding in yeast and are also conserved in the mouse. In addition, there is a conserved zinc-finger domain in region I and a conserved RING-H2 domain in region IV (Kwon *et al.*, *Proc. Natl. Acad. Sci., U.S.A.*, 95: 7898-7903, 1999).

The full length mouse E3 α cDNA sequence and a partial human E3 α nucleotide sequence (≈ 1 kb) have recently been cloned and characterized as described in US 5,861,312 and Kwon *et al.* (*Proc. Natl. Acad. U.S.A.*, 95: 7898-7908, 1999). The full length mouse E3 α cDNA sequence is 5271 bp in length and encodes a 1757 amino acid polypeptide. The mouse E3 α gene is localized to the central region of chromosome 2 and is highly expressed in skeletal muscle, heart and brain. The partial human E3 α sequence was used to characterize tissue expression and chromosomal localization. This analysis indicated that the human E3 α gene is located on chromosome 15q and exhibits a similar expression pattern as mouse E3 α with high expression in skeletal muscle, heart and brain. As described herein, the present invention discloses two novel, full length, human E3 α sequences (huE3 α I and huE3 α II) and a novel, full length mouse E3 α sequence (muE3 α II). Expression of huE3 α I and huE3 α II mRNA is highly enriched in skeletal muscle tissues. Functionally, huE3 α polypeptides are intracellular enzymes that control protein conjugation and degradation.

Increased proteolysis through the ubiquitin-proteasome pathway has been determined to be a major cause of rapid muscle wasting in many pathological states including but not limited to fasting, metabolic acidosis, muscle denervation, kidney failure, renal cachexia, uremia, diabetes mellitus, sepsis, AIDS wasting syndrome, cancer cachexia, negative nitrogen balance cachexia, burns and Cushing's syndrome (See Mitch and Goldberg, *New England J. Med.*, 335: 1897-1905, 1996). Studies in animal models have shown that muscle wasting disorders are associated with increased ubiquitin content in muscles, increased levels of mRNA transcripts encoding ubiquitin, E2 enzyme and proteasome subunit mRNA, and increased ubiquitin-conjugation to muscle-proteins (See Lecker *et al.*, *J. Nutr.*, 129: 227S-237S, 1999). In this context, the N-end rule

pathway has been shown to play a role in muscle atrophy. E3 α inhibitors, such as dipeptides and methyl ester, reduce the level of ubiquitin conjugation in atrophying rat muscles caused by sepsis, fasting and cancer cachexia (Soloman *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 95: 12602-12607, 1999). These observations indicate that E3 α plays a role in the overall increase in ubiquitination that is associated with and may mediate muscle atrophy in catabolic and other disease states.

Thus, identification of members of the N-end rule protein degradation pathway has led to a better understanding of protein degradation in human cells and the mechanisms of protein degradation in pathological condition which involve muscle atrophy. Identification of the two novel human E3 α ubiquitin ligase genes and polypeptides, as described herein, will further clarify the understanding of these processes and facilitate the development of therapies for pathological conditions which involve abnormal or excessive protein degradation including conditions which involve atrophy of muscle.

SUMMARY OF THE INVENTION

The present invention relates to novel human E3 α nucleic acid molecules and polypeptides encoded by these nucleic acid molecules.

The invention provides isolated nucleic acid molecules comprising or consisting of a nucleotide sequence selected from the group consisting of:

- a) the nucleotide sequence as set forth in SEQ ID NOS: 1 or 3 ;
- b) a nucleotide sequence encoding the polypeptide set forth in SEQ ID NOS: 2 and 4;
- c) a nucleotide sequence which hybridizes under moderate or highly stringent conditions to the compliments of (a) or (b); and
- d) a nucleotide complementary to (a) - (c)

The invention also provides isolated nucleic acid molecules comprising a nucleotide sequence selected from the group consisting of:

- a) a nucleotide sequence encoding a polypeptide that is at least about 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent identical to the polypeptide set forth in SEQ ID NOS: 2 or 4, wherein the polypeptide has an activity of the polypeptide set forth in SEQ

ID NOS: 2 or 4 and the percent identity for these nucleic acid sequences are determined using a computer program selected from the group consisting of GAP, BLASTP, BLASTN, FASTA, BLASTA, BLASTX, BestFit, and the Smith-Waterman algorithm;

- b) a nucleotide sequence encoding an allelic variant or splice variant of the nucleotide sequence as set forth in SEQ ID NOS: 1 or 3;
- c) the nucleotide sequence of the DNA insert in ATCC Deposit No. PTA-1489 or PTA-1490;
- d) a nucleotide sequence of SEQ ID NOS: 1; 3; (a); or (b) encoding a polypeptide fragment of at least about 25 amino acid residues, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;
- e) a nucleotide sequence of SEQ ID NOS: 1, 3, or (a)-(c) comprising a fragment of at least about 16 nucleotides;
- f) a nucleotide sequence which hybridizes under moderately or highly stringent conditions to the complement of any of (a)-(e); and
- g) a nucleotide sequence complementary to any of (a)-(d).

The invention also provides isolated nucleic acid molecules comprising a nucleotide sequence selected from the group consisting of:

- a) a nucleotide sequence encoding a polypeptide set forth in SEQ ID NOS: 2 or 4 with at least one conservative amino acid substitution, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;
- b) a nucleotide sequence encoding a polypeptide set forth in SEQ ID NOS: 2 or 4 with at least one amino acid insertion, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;
- c) a nucleotide sequence encoding a polypeptide set forth in SEQ ID NOS: 2 or 4 with at least one amino acid deletion, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;
- d) a nucleotide sequence encoding a polypeptide set forth in SEQ ID NOS: 2 or 4 which has a C- and/or N- terminal truncation, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;
- e) a nucleotide sequence encoding a polypeptide set forth in SEQ ID NOS: 2 or 4 with at least one modification selected from the group consisting of amino acid

substitutions, amino acid insertions, amino acid deletions, C-terminal truncation, and N-terminal truncation, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;

f) a nucleotide sequence of (a)-(e) comprising a fragment of at least about 16 nucleotides;

g) a nucleotide sequence which hybridizes under moderately or highly stringent conditions to the complement of any of (a)-(f); and

h) a nucleotide sequence complementary to any of (a)-(e).

The invention also provides isolated polypeptides comprising the amino acid sequence selected from the group consisting of:

a) the amino acid sequence as set forth in SEQ ID NOS: 2 or 4;

b) the mature amino acid sequence as set forth in SEQ ID NOS: 2 or 4 comprising a mature amino terminus at residues 1, and optionally further comprising an amino terminal methionine;

c) an amino acid sequence that is at least about 70, 75, 80, 85, 90, 95, 96, 97, 98, or 99 percent identical to the amino acid sequence of the polypeptide of SEQ ID NOS: 2 or 4 wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4 and the percent identity for these amino acid sequences are determined using a computer program selected from the group consisting of GAP, BLASTP, BLASTN, FASTA, BLASTA, BLASTX, BestFit, and the Smith-Waterman algorithm.

d) a fragment of the amino acid sequence set forth in SEQ ID NOS: 2 or 4 comprising at least about 25, 50, 75, 100, or greater than 100 amino acid residues, wherein the fragment has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;

e) the amino acid sequence encoded by the DNA insert of ATCC Deposit No. PTA-1489 or PTA-1490;

f) an amino acid sequence for an ortholog of SEQ ID NOS: 2 or 4; including the murine ortholog set out as SEQ ID NO: 6.

g) an allelic variant or splice variant of (a), (b), (e) or (f);

The present invention also provides isolated polypeptides comprising the amino acid sequence selected from the group consisting of:

a) the amino acid sequence set forth in SEQ ID NOS: 2 or 4 with at least one conservative amino acid substitution, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;

b) the amino acid sequence as set forth in SEQ ID NOS: 2 or 4 with at least one amino acid insertion, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;

c) the amino acid sequence as set forth in SEQ ID NOS: 2 or 4 with at least one amino acid deletion, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4;

d) the amino acid sequence as set forth in SEQ ID NOS: 2 or 4 which has a C- and/or N- terminal truncation, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4; and

e) the amino acid sequence as set forth in SEQ ID NOS: 2 or 4, with at least one modification selected from the group consisting of amino acid substitutions, amino acid insertions, amino acid deletions, C-terminal truncation, and N-terminal truncation, wherein the polypeptide has an activity of the polypeptide set forth in SEQ ID NOS: 2 or 4.

The present invention provides expression vectors comprising the nucleic acid molecules set forth herein, host cells comprising the expression vectors of the invention, and a method of producing a human E3 α polypeptide comprising culturing the host cells and optionally isolating the polypeptide so produced. Another embodiment provides for viral vectors comprising the nucleic acid molecules of the inventions. Further provided is a process for determining whether a compound inhibits huE3 α polypeptide activity or production comprising exposing a host cell expressing huE3 α polypeptide to the compound, and measuring huE3 α polypeptide activity or production in said cell.

A transgenic non-human animal comprising a nucleic acid molecule encoding a huE3 α polypeptide is also encompassed by the invention. The huE3 α nucleic acid molecules are introduced into the animal in a manner that allows expression and

increased levels of a huE3 α polypeptide, which may include increased circulating levels. The transgenic non-human animal is preferably a mammal, and more preferably a rodent, such as a rat or a mouse.

5 Also provided are derivatives of the huE3 α polypeptides of the present invention, fusion polypeptides comprising the huE3 α polypeptides of the invention, and selective binding agents such as antibodies capable of specifically binding the polypeptides of the invention.

10 Pharmaceutical compositions comprising the nucleotides, polypeptides, or selective binding agents of the present invention and a carrier, adjuvant, solubilizer, stabilizer, anti-oxidant, or other pharmaceutically acceptable formulation agent are also encompassed by the invention. The pharmaceutical compositions include therapeutically effective amounts of the nucleotides or polypeptides of the present invention, and involve methods of using the polypeptides and nucleic acid molecules.

15 The huE3 α polypeptides and nucleic acid molecules of the present invention may be used for therapeutic or diagnostic purposes to treat, prevent, and/or detect diseases or disorders, including those recited herein.

20 Methods of regulating expression and modulating (*i.e.*, increasing or decreasing) levels of a huE3 α polypeptide are also encompassed by the invention. One method comprises administering to an animal a nucleic acid molecule encoding a huE3 α polypeptide. In another method, a nucleic acid molecule comprising elements that regulate or modulate the expression of a huE3 α polypeptide may be administered. Examples of these methods include gene therapy, cell therapy and antisense therapy as further described herein. Further provided is a method of identifying a compound which binds to a huE3 α polypeptide comprising.

25 A device, comprising a membrane suitable for implantation and host cells expressing a huE3 α polypeptide encapsulated within said membrane, wherein said membrane is permeable to said protein product and impermeable to materials detrimental to said cells is also encompassed by the present invention.

30 BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the alignment of the amino acid sequences for huE3 α I, huE3 α II, muE3 α I and muE3 α II (SEQ ID NOS: 2, 4, 15 and 6, respectively).

Figure 2 shows the results of a human multiple tissue Northern blot detecting huE3 α II expression.

Figure 3 shows the results of a human multiple tissue Northern blot detecting huE3 α I expression.

5 Figure 4 shows that transfection of 293T cells with huE3 α I and huE3II cDNA stimulates the ubiquitination of endogenous proteins and exogenously added α -lactalbumin in cell lysates. The left panel shows the results of gel-shift assays of ubiquitinated proteins. The high molecular weight bands (above 18 kDa for endogenous proteins and above 33 kDa for α -lactalbumin) are identified as "¹²⁵I- Ubiquitin-protein conjugates". The left panel plots the quantitative measurement of ubiquitinated proteins measured by a PhosphorImager.

10 Figure 5 shows that transfection of C₂C₁₂ and L6 myotube cells with huE3 α I and huE3II cDNA stimulates the ubiquitination of endogenous proteins cell lysates. The left panel shows the ubiquitinated high molecular weight bands (above 18 kDa for endogenous proteins) as "¹²⁵I- Ubiquitin-protein conjugates". The left panel plots the quantitative measurement of ubiquitinated proteins measured by a PhosphorImager.

15 Figure 6 shows the ¹²⁵I-ubiquitin conjugation to endogenous muscle proteins and its sensitivity to selective inhibitors of E3 α in muscle extracts from control and YAH-tumor bearing rats. Gel-shift assays of muscle extracts from control and tumor-bearing rats revealed the ubiquitinated high molecular weight bands (above 18 kDa) denoted as "¹²⁵I- Ubiquitin-protein conjugates". The left panel is muscle extracts collected 3 days post-implantation and the right panel is muscle extracts collected 5 days post-implantation.

20 Figure 7 shows the ubiquitin conjugation to ¹²⁵I- α -lactalbumin in extracts from atrophying muscles in YAH-tumor bearing rats as western blots of muscle extracts from control and tumor-bearing rats with the ubiquitinated high molecular weight bands (above 33 kDa) as "¹²⁵I-Lactalbumin-ubiquitin conjugation ". The left panel is muscle extracts collected 3 days post-implantation and the right panel is muscle extracts collected 5 days post-implantation.

25 Figure 8 shows Northern blot analysis of E3 α I and E3 α II expression in skeletal muscle in YAH-130 experimental cachexia model. The RNA expression

from pair-fed control rats and tumor-bearing rats were compared 3 days (3d) and 5 days (5d) post-implantation.

Figure 9 shows Northern blot analysis of E3 α I and E3 α II expression in skeletal (gastrocnemius) muscle and cardiac muscle in the C26 experimental cacheixia model. The RNA expression from pair-fed control rats and tumor-bearing mice were compared 12 days (12d) and 17 days (17d) post-implantation.

Figure 10 shows induction of E3 α II expression by proinflammatory cytokines TNF α and IL-6 in C₂C₁₂ myotube cultures on Northern blots. The RNA levels of E3 α II (upper panel) and E3 α I (lower panel) were detected 3 or 5 days after treatment with TNF α (left panel) and IL-6 (right panel).

Figure 11 shows that IL-6 treatment causes a time-dependent acceleration of ubiquitination in differentiated C₂C₁₂ cells. This data exhibits the results of a gel-shift assay showing the ubiquitinated high molecular weight bands denoted as “¹²⁵I-ubiquitin protein conjugates”(left panel) and is quantitated by a PhosphorImager in the right panel.

Figure 12 shows that TNF α treatment causes a dose-dependent acceleration of ubiquitination in differentiated C₂C₁₂ cells. This data is displayed as gel-shift assay results with the ubiquitinated high molecular weight bands denoted as “¹²⁵I-ubiquitin protein conjugates” (left panel) and is quantitated by a PhosphorImager in the right panel.

DETAILED DESCRIPTION OF THE INVENTION

The section headings used herein are for organizational purposes only and are not to be construed as limiting the subject matter described therein. All references cited in this application are expressly incorporated by reference herein.

Definitions

The term “huE3 α ” encompasses two novel orthologs of human E3 α ubiquitin ligase described herein including huE3 α I polynucleotide and polypeptide (SEQ ID NOS: 1 and 2, respectively) and huE3 α II polynucleotide and polypeptide (SEQ ID NOS: 3 and 4, respectively).

The term "huE3 α nucleic acid molecule" or "polynucleotide" refers to a nucleic acid molecules including a nucleotide sequence as set forth in SEQ ID NOS: 1 or 3, a nucleotide sequence encoding the polypeptide set forth in SEQ ID NOS: 2 or 4, a nucleotide sequence of the DNA insert in ATCC deposit nos. PTA-1489 or PTA-1490, or nucleic acid molecule related thereto. Related nucleic acid molecules include a nucleotide sequence that is at least about 70 percent identical to the nucleotide sequence as shown in SEQ ID NOS: 1 or 3, or comprise or consist essentially of a nucleotide sequence encoding a polypeptide that is at least about 70 percent identical to the polypeptide set forth in SEQ ID NOS: 2 or 4. In preferred embodiments, these nucleotide sequences are about 75 percent, or about 80 percent, or about 85 percent, or about 90 percent, or about 95, 96, 97, 98, or 99 percent identical to the nucleotide sequence as shown in SEQ ID NOS: 1 or 3, or the nucleotide sequences encode a polypeptide that is about 75 percent, or about 80 percent, or about 85 percent, or about 90 percent, or about 95, 96, 97, 98, or 99 percent identical to the polypeptide sequence as set forth in SEQ ID NOS: 2 or 4.

Related nucleic acid molecules also include fragments of the huE3 α I or hu E3 α II nucleic acid molecules which fragments contain at least about 10 contiguous nucleotides, or about 15, or about 20, or about 25, or about 50, or about 75, or about 100, or greater than about 100 contiguous nucleotides of a huE3 α nucleic acid molecule of SEQ ID NOS: 1 or 3. Related nucleic acid molecules also include fragments of the above huE3 α nucleic acid molecules which encode a polypeptide of at least about 25 amino acid residues, or about 50, or about 75, or about 100, or greater than about 100 amino acid residues of the huE3 α polypeptide of SEQ ID NOS: 2 or 4. Related nucleic acid molecules also include a nucleotide sequence encoding a polypeptide comprising or consisting essentially of a substitution, modification, addition and/or a deletion of one or more amino acid residues compared to the polypeptide set forth in SEQ ID NOS: 2 or 4. In addition, related huE3 α nucleic acid molecules include those molecules which comprise nucleotide sequences which hybridize under moderately or highly stringent conditions as defined herein with the fully complementary sequence of any of the huE3 α nucleic acid molecules of SEQ ID NOS: 1 or 3.

In preferred embodiments, the related nucleic acid molecules comprise sequences which hybridize under moderately or highly stringent conditions with a molecule having a sequence as shown in SEQ ID NOS: 1 or 3, or of a molecule encoding a polypeptide, which polypeptide comprises the sequence as shown in SEQ ID NOS: 2 or 4, or of a nucleic acid fragment as defined herein, or of a nucleic acid fragment encoding a polypeptide as defined herein or the complement of any or the foregoing molecules. It is also understood that related nucleic acid molecules include allelic or splice variants of a huE3 α nucleic acid molecule of SEQ ID NOS: 1 or 3, and include sequences which are complementary to any of the above nucleotide sequences. The related encoded polypeptides possess at least one activity of the polypeptide depicted in SEQ ID NOS: 2 or 4.

The term "isolated nucleic acid molecule" refers to a nucleic acid molecule of the invention that is free from at least one contaminating nucleic acid molecule with which it is naturally associated. Preferably, the isolated nucleic acid molecule of the present invention is substantially free from any other contaminating mammalian nucleic acid molecule(s) which would interfere with its use in polypeptide production or its therapeutic, diagnostic, or preventative use.

A "nucleic acid sequence" or "nucleic acid molecule" as used herein refer to a DNA or RNA sequence. The terms encompasses molecules formed from any of the known base analogs of DNA and RNA such as, but not limited to 4-acetylcytosine, 8-hydroxy-N6-methyladenosine, aziridinyl-cytosine, pseudoisocytosine, 5-(carboxyhydroxymethyl) uracil, 5-fluorouracil, 5-bromouracil, 5-carboxymethylaminomethyl-2-thiouracil, 5-carboxy-methylamino-methyluracil, dihydrouracil, inosine, N6-iso-pentenyladenine, 1-methyladenine, 1-methylpseudouracil, 1-methylguanine, 1-methylinosine, 2,2-dimethyl-guanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-methyladenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarbonyl-methyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid, oxybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-

methyluracil, N-uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid, pseudouracil, queosine, 2-thiocytosine, and 2,6-diaminopurine.

The term "operably linked" is used as recognized in the art to refer to an arrangement of flanking sequences wherein the flanking sequences so described are configured or assembled so as to perform their usual function. Thus, a flanking sequence operably linked to a coding sequence may be capable of effecting the replication, transcription and/or translation of the coding sequence. For example, a coding sequence is operably linked to a promoter when the promoter is capable of directing transcription of that coding sequence. A flanking sequence need not be contiguous with the coding sequence, so long as it functions correctly. Thus, for example, intervening untranslated yet transcribed sequences can be present between a promoter sequence and the coding sequence and the promoter sequence can still be considered "operably linked" to the coding sequence.

The term "pharmaceutically acceptable carrier" or "physiologically acceptable carrier" as used herein refer to one or more formulation materials suitable for accomplishing or enhancing delivery of the huE3 α polypeptide, huE3 α nucleic acid molecule, or huE3 α selective binding agent as a pharmaceutical composition.

The term "allelic variant" refers to one of several possible naturally occurring alternate forms of a gene occupying a given locus on a chromosome of an organism or a population of organisms.

The term "splice variant" refers to a nucleic acid molecule, usually RNA, which is generated by alternative processing of intron sequences in an RNA transcript of huE3 α polypeptide amino acid sequence.

The term "expression vector" refers to a vector which is suitable for transformation of a host cell and contains nucleic acid sequences which direct and/or control the expression of inserted heterologous nucleic acid sequences. Expression includes, but is not limited to, processes such as transcription, translation, and RNA splicing, if introns are present.

The term "vector" is used as recognized in the art to refer to any molecule (e.g., nucleic acid, plasmid, or virus) used to transfer coding information to a host cell.

The term "transformation" as used herein refers to a change in a cell's genetic characteristics, and a cell has been transformed when it has been modified to contain a new DNA. For example, a cell is transformed where it is genetically modified from its native state. Following transfection or transduction, the transforming DNA may recombine with that of the cell by physically integrating into a chromosome of the cell, may be maintained transiently as an episomal element without being replicated, or may replicate independently as a plasmid. A cell is considered to have been stably transformed when the DNA is replicated with the division of the cell.

The term "transfection" is used to refer to the uptake of foreign or exogenous DNA by a cell, and a cell has been "transfected" when the exogenous DNA has been introduced inside the cell membrane. A number of transfection techniques are well known in the art and are disclosed herein. See, for example, Graham *et al.*, *Virology*, 52: 456, 1973; Sambrook *et al.*, *Molecular Cloning, A Laboratory Manual*, Cold Spring Harbor Laboratories, New York, 1989; Davis *et al.*, *Basic Methods in Molecular Biology*, Elsevier, 1986; and Chu *et al.*, *Gene*, 13: 197, 1981. Such techniques can be used to introduce one or more exogenous DNA moieties into suitable host cells.

The term "transduction" is used to refer to the transfer of genes from one bacterium to another, usually by a phage. "Transduction" also refers to the acquisition and transfer of eukaryotic cellular sequences by retroviruses.

The term "host cell" is used to refer to a cell which has been transformed, or is capable of being transformed, by a vector bearing a selected gene of interest which is then expressed by the cell. The term includes the progeny of the parent cell, whether or not the progeny is identical in morphology or in genetic make-up to the original parent, so long as the selected gene is present.

The term "highly stringent conditions" refers to those conditions that are designed to permit hybridization of DNA strands whose sequences are highly complementary, and to exclude hybridization of significantly mismatched DNAs. Hybridization stringency is principally determined by temperature, ionic strength, and the concentration of denaturing agents such as formamide. Examples of "highly stringent conditions" for hybridization and washing are 0.015 M sodium chloride,

0.0015 M sodium citrate at 65-68°C or 0.015 M sodium chloride, 0.0015M sodium citrate, and 50% formamide at 42°C. See Sambrook, Fritsch & Maniatis, *Molecular Cloning: A Laboratory Manual*, 2nd Ed., Cold Spring Harbor Laboratory, (Cold Spring Harbor, N.Y. 1989); Anderson *et al.*, *Nucleic Acid Hybridisation: A Practical Approach*, Ch. 4, IRL Press Limited (Oxford, England).

More stringent conditions (such as higher temperature, lower ionic strength, higher formamide, or other denaturing agent) may also be used, however, the rate of hybridization will be affected. Other agents may be included in the hybridization and washing buffers for the purpose of reducing non-specific and/or background hybridization. Examples are 0.1% bovine serum albumin, 0.1% polyvinyl-pyrrolidone, 0.1% sodium pyrophosphate, 0.1% sodium dodecylsulfate, NaDodSO₄, or SDS, ficoll, Denhardt's solution, sonicated salmon sperm DNA (or other non-complementary DNA), and dextran sulfate, although another suitable agents can also be used. The concentration and types of these additives can be changed without substantially affecting the stringency of the hybridization conditions. Hybridization experiments are usually carried out at pH 6.8-7.4, however, at typical ionic strength conditions, the rate of hybridization is nearly independent of pH. (See Anderson *et al.*, *Nucleic Acid Hybridisation: a Practical Approach*, Ch. 4, IRL Press Limited (Oxford, England)).

Factors affecting the stability of DNA duplex include base composition, length, and degree of base pair mismatch. Hybridization conditions can be adjusted by one skilled in the art in order to accommodate these variables and allow DNAs of different sequence relatedness to form hybrids. The melting temperature of a perfectly matched DNA duplex can be estimated by the following equation:

$$T_m(^{\circ}\text{C}) = 81.5 + 16.6(\log[\text{Na}^+]) + 0.41(\% \text{G+C}) - 600/N - 0.72(\% \text{formamide})$$

where N is the length of the duplex formed, [Na⁺] is the molar concentration of the sodium ion in the hybridization or washing solution, %G+C is the percentage of (guanine+cytosine) bases in the hybrid. For imperfectly matched hybrids, the melting temperature is reduced by approximately 1°C for each 1% mismatch.

The term "moderately stringent conditions" refers to conditions under which a DNA duplex with a greater degree of base pair mismatching than could occur under "highly stringent conditions" is able to form. Examples of typical "moderately

stringent conditions" are 0.01 5M sodium chloride, 0.0015 M sodium citrate at 50-65°C or 0.015 M sodium chloride, 0.0015 M sodium citrate, and 20% formamide at 37-50°C. By way of example, a "moderately stringent" condition of 50°C in 0.015 M sodium ion will allow about a 21% mismatch.

5 It will be appreciated by those skilled in the art that there is no absolute distinction between "highly" and "moderately" stringent conditions. For example, at 0.015M sodium ion (no formamide), the melting temperature of perfectly matched long DNA is about 71°C. With a wash at 65°C (at the same ionic strength), this would allow for approximately a 6% mismatch. To capture more distantly
10 related sequences, one skilled in the art can simply lower the temperature or raise the ionic strength.

A good estimate of the melting temperature in 1 M NaCl* for oligonucleotide probes up to about 20 nt is given by:

$$T_m = 2^{\circ}\text{C per A-T base pair} + 4^{\circ}\text{C per G-C base pair}$$

15 *The sodium ion concentration in 6x salt sodium citrate (SSC) is 1M. See Suggs *et al.*, *Developmental Biology Using Purified Genes*, p. 683, Brown and Fox (eds.) (1981).

High stringency washing conditions for oligonucleotides are usually at a temperature of 0-5°C below the T_m of the oligonucleotide in 6x SSC, 0.1% SDS for
20 longer nucleotides.

The term "huE3 α polypeptide" refers to a polypeptide comprising the amino acid sequence of huE3 α I or huE3 α II (SEQ ID NOS: 2 or 4, respectively), and related polypeptides having a natural sequence or mutated sequence. Related polypeptides include: allelic variants; splice variants; fragments; derivatives; substitution, deletion, and insertion variants; fusion polypeptides; and orthologs of the
25 huE3 α polypeptides of SEQ ID NOS: 2 or 4, which possess at least one activity of the polypeptide depicted in SEQ ID NOS: 2 or 4. Human E3 α polypeptides may be mature polypeptides, as defined herein, and may or may not have an amino terminal methionine residue, depending on the method by which they are prepared.

30 The term "huE3 α polypeptide fragment" refers to a polypeptide that comprises less than the full length amino acid sequence of a huE3 α I or huE3 α II polypeptide set forth in SEQ ID NOS: 2 or 4, respectively. Such huE3 α fragments can be 6 amino acids or more in length, and may arise, for example, from a truncation at the

amino terminus (with or without a leader sequence), a truncation at the carboxy terminus, and/or an internal deletion of one or more residues from the amino acid sequence. Human E3 α fragments may result from alternative RNA splicing or from *in vivo* protease activity. Membrane-bound forms of huE3 α are also contemplated by the present invention. In preferred embodiments, truncations and/or deletions comprise about 10 amino acids, or about 20 amino acids, or about 50 amino acids, or about 75 amino acids, or about 100 amino acids, or more than about 100 amino acids. The polypeptide fragments so produced will comprise about 25 contiguous amino acids, or about 50 amino acids, or about 75 amino acids, or about 100 amino acids, or about 150 amino acids, or about 200 amino acids. Such huE3 α polypeptide fragments may optionally comprise an amino terminal methionine residue. It will be appreciated that such fragments can also be used, for example, to generate antibodies to huE3 α polypeptides.

The term "huE3 α polypeptide variants" refers to huE3 α polypeptides which contain one or more amino acid sequence substitutions, deletions, and/or additions as compared to the huE3 α polypeptide amino acid sequence set forth as huE3 α I or huE3 α II (SEQ ID NOS: 2 or 4, respectively). Variants may be naturally occurring or artificially constructed. Such huE3 α polypeptide variants may be prepared from the corresponding nucleic acid molecules encoding said variants, which have a DNA sequence that varies accordingly from the DNA sequences for wild type huE3 α polypeptides as set forth in SEQ ID NOS: 1 or 3. In preferred embodiments, the variants have from 1 to 3, or from 1 to 5, or from 1 to 10, or from 1 to 20, or from 1 to 25, or from 1 to 50, or from 1 to 75, or from 1 to 100, or more than 100 amino acid substitutions, insertions, additions and/or deletions, wherein the substitutions may be conservative, or non-conservative, or any combination thereof.

One skilled in the art will be able to determine suitable variants of the native huE3 α polypeptide using well known techniques. For example, one may predict suitable areas of the molecule that may be changed without destroying biological activity. Also, one skilled in the art will realize that even areas that may be important for biological activity or for structure may be subject to conservative amino acid substitutions without destroying the biological activity or without adversely affecting the polypeptide structure.

For predicting suitable areas of the molecule that may be changed without destroying activity, one skilled in the art may target areas not believed to be important for activity. For example, when similar polypeptides with similar activities from the same species or from other species are known, one skilled in the art may compare the amino acid sequence of huE3 α polypeptide to such similar polypeptides. After making such a comparison, one skilled in the art can determine residues and portions of the molecules that are conserved among similar polypeptides. One skilled in the art would know that changes in areas of the huE3 α molecule that are not conserved would be less likely to adversely affect the biological activity and/or structure of a huE3 α polypeptide. One skilled in the art would also know that, even in relatively conserved regions, one may substitute chemically similar amino acids for the naturally occurring residues while retaining activity (conservative amino acid residue substitutions).

Additionally, one skilled in the art can review structure-function studies identifying residues in similar polypeptides that are important for activity or structure. In view of such a comparison, one skilled in the art can predict the importance of amino acid residues in a huE3 α polypeptide that correspond to amino acid residues that are important for activity or structure in similar polypeptides. One skilled in the art may opt for chemically similar amino acid substitutions for such predicted important amino acid residues of huE3 α polypeptides.

If available, one skilled in the art can also analyze the three-dimensional structure and amino acid sequence in relation to that structure in similar polypeptides. In view of that information, one skilled in the art may predict the alignment of amino acid residues of huE3 α polypeptide with respect to its three dimensional structure. One skilled in the art may choose not to make radical changes to amino acid residues predicted to be on the surface of the protein, since such residues may be involved in important interactions with other molecules.

Additional methods of predicting secondary structure include "threading" (Jones *et al.*, *Current Opin. Struct. Biol.*, 7(3):377-87 (1997); Sippl *et al.*, *Structure*, 4(1):15-9 (1996)), "profile analysis" (Bowie *et al.*, *Science*, 253:164-170 (1991); Gribskov *et al.*, *Meth. Enzym.*, 183:146-159 (1990); Gribskov *et al.*, *Proc. Nat. Acad. Sci.*, 84(13):4355-4358 (1987)), and "evolutionary linkage" (See Home, *supra*, and Brenner, *supra* 1997).

Moreover, one skilled in the art may generate test variants containing a single amino acid substitution at each amino acid residue. The variants could be screened using activity assays described herein. Such variants could be used to gather information about suitable variants. For example, if one discovered that a change to a particular amino acid residue resulted in destroyed, undesirably reduced, or unsuitable activity, variants with such a change would be avoided. In other words, based on information gathered from such routine experiments, one skilled in the art can readily determine the amino acids where further substitutions should be avoided either alone or in combination with other mutations.

In making such changes, the hydropathic index of amino acids may be considered. Each amino acid has been assigned a its hydropathic index on the basis of its hydrophobicity and charge characteristics. They are: isoleucine (+4.5); valine (+4.2); leucine (+3.8); phenylalanine (+2.8); cysteine/cystine (+2.5); methionine (+1.9); alanine (+1.8); glycine (-0.4); threonine (-0.7); serine (-0.8); tryptophan (-0.9); tyrosine (-1.3); proline (-1.6); histidine (-3.2); glutamate (-3.5); glutamine (-3.5); aspartate (-3.5); asparagine (-3.5); lysine (-3.9); and arginine (-4.5).

The importance of the hydropathic amino acid index in conferring interactive biological function on a protein is generally understood in the art (Kyte *et al.*, *J. Mol. Biol.*, 157: 105-131, 1982). It is known that certain amino acids may be substituted for other amino acids having a similar hydropathic index or score and still retain a similar biological activity. In making changes based upon the hydropathic index, the substitution of amino acids whose hydropathic indices are within ± 2 is preferred, those which are within ± 1 are particularly preferred, and those within ± 0.5 are even more particularly preferred.

It is also understood in the art that the substitution of like amino acids can be made effectively on the basis of hydrophilicity, particularly where the biologically functionally equivalent protein or peptide thereby created is intended for use in immunological embodiments, as in the present case.

The U.S. Patent No. 4,554,101 states that the greatest local average hydrophilicity of a protein, as governed by the hydrophilicity of its adjacent amino acids, correlates with its immunogenicity and antigenicity, *i.e.*, with a biological property of the protein. As detailed in U.S. Patent No. 4,554,101, the following hydrophilicity

values have been assigned to amino acid residues: arginine (+3.0); lysine (+3.0); aspartate (+3.0 \pm 1); glutamate (+3.0 \pm 1); serine (+0.3); asparagine (+0.2); glutamine (+0.2); glycine (0); threonine (-0.4); proline (-0.5 \pm 1); alanine (-0.5); histidine (-0.5); cysteine (-1.0); methionine (-1.3); valine (-1.5); leucine (-1.8); isoleucine (-1.8); tyrosine (-2.3); phenylalanine (-2.5); and tryptophan (-3.4).

In making changes based upon similar hydrophilicity values, the substitution of amino acids whose hydrophilicity values are within ± 2 is preferred, those which are within ± 1 are particularly preferred, and those within ± 0.5 are even more particularly preferred. One may also identify epitopes from primary amino acid sequences on the basis of hydrophilicity. Through the methods disclosed in U.S. Patent No. 4,554,101 one of skill in the art is able to identify epitopes from within a given amino acid sequence. These regions are also referred to as "epitopic core regions".

Numerous scientific publications have been devoted to the prediction of secondary structure, and to the identification of epitopes, from analyses of amino acid sequences. See Chou *et al.*, *Biochemistry*, 13(2): 222-245, 1974; Chou *et al.*, *Biochemistry*, 113(2): 211-222, 1974; Chou *et al.*, *Adv. Enzymol. Relat. Areas Mol. Biol.*, 47: 45-148, 1978; Chou *et al.*, *Ann. Rev. Biochem.*, 47: 251-276 and Chou *et al.*, *Biophys. J.*, 26: 367-384, 1979. Moreover, computer programs are currently available to assist with predicting antigenic portions and epitopic core regions of proteins. Examples include those programs based upon the Jameson-Wolf analysis (Jameson *et al.*, *Comput. Appl. Biosci.*, 4(1): 181-186, 1988 and Wolf *et al.*, *Comput. Appl. Biosci.*, 4(1): 187-191, 1988, the program PepPlot® (Brutlag *et al.*, *CABS*, 6: 237-245 1990, and Weinberger *et al.*, *Science*, 228: 740-742, 1985) and other new programs for protein tertiary structure prediction (Fetrow *et al.*, *Biotechnology*, 11: 479-483 1993).

In preferred embodiments, the variants have from 1 to 3, or from 1 to 5, or from 1 to 10, or from 1 to 15, or from 1 to 20, or from 1 to 25, or from 1 to 50, or from 1 to 75, or from 1 to 100, or more than 100 amino acid substitutions, insertions, additions and/or deletions, wherein the substitutions may be conservative, as described herein, or non-conservative, or any combination thereof. In addition, the variants can have additions of amino acid residues either at the carboxy terminus or at the amino terminus (with or without a leader sequence).

Preferred huE3 α polypeptide variants include glycosylation variants wherein the number and/or type of glycosylation sites has been altered compared to native huE3 α polypeptide. In one embodiment, huE3 α polypeptide variants comprise a greater or a lesser number of N-linked glycosylation sites. An N-linked glycosylation site is characterized by the sequence: Asn-X-Ser or Asn-X-Thr, wherein the amino acid residue designated as X may be any amino acid residue except proline. The substitution(s) of amino acid residues to create this sequence provides a potential new site for the addition of an N-linked carbohydrate chain. Alternatively, substitutions which eliminate this sequence will remove an existing N-linked carbohydrate chain. Also provided is a rearrangement of N-linked carbohydrate chains wherein one or more N-linked glycosylation sites (typically those that are naturally occurring) are eliminated and one or more new N-linked sites are created. Additional preferred huE3 α variants include cysteine variants, wherein one or more cysteine residues are deleted or substituted with another amino acid (*e.g.*, serine). Cysteine variants are useful when huE3 α polypeptides must be refolded into a biologically active conformation such as after the isolation of insoluble inclusion bodies. Cysteine variants generally have fewer cysteine residues than the native protein, and typically have an even number to minimize interactions resulting from unpaired cysteines.

The term "huE3 α fusion polypeptide" refers to a fusion of huE3 α I or huE3 α II polypeptide, fragment, and/or variant thereof, with a heterologous peptide or polypeptide. In addition, the polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or 4 or huE3 α polypeptide variant may be fused to a homologous polypeptide to form a homodimer or to a heterologous polypeptide to form a heterodimer. Heterologous peptides and polypeptides include, but are not limited to: an epitope to allow for the detection and/or isolation of a huE3 α fusion polypeptide; a transmembrane receptor protein or a portion thereof, such as an extracellular domain, or a transmembrane and intracellular domain; a ligand or a portion thereof which binds to a transmembrane receptor protein; an enzyme or portion thereof which is catalytically active; a polypeptide or peptide which promotes oligomerization, such as a leucine zipper domain; a polypeptide or peptide which increases stability, such as an immunoglobulin constant region, and a polypeptide which has a therapeutic activity different from the huE3 α polypeptide.

In addition, a huE3 α polypeptide may be fused to itself or to a fragment, variant, or derivative thereof. Fusions can be made either at the amino terminus or at the carboxy terminus of a huE3 α polypeptide. Fusions may be direct with no linker or adapter molecule or indirect using through a linker or adapter molecule. A linker or adapter molecule may be one or more amino acid residues, typically from 20 amino acids residues, or up to about 50 amino acid residues. A linker or adapter molecule may also be designed with a cleavage site for a DNA restriction endonuclease or for a protease to allow for the separation of the fused moieties. It will be appreciated that once constructed, the fusion polypeptides can be derivatized according to the methods described herein.

In a further embodiment of the invention, a huE3 α polypeptide, including a fragment, variant, and/or derivative, is fused to an Fc region of human IgG. Antibodies comprise two functionally independent parts, a variable domain known as "Fab", which binds antigens, and a constant domain known as "Fc", which is involved in effector functions such as complement activation and attack by phagocytic cells. An Fc has a long serum half-life, whereas an Fab is short-lived (Capon *et al.*, *Nature*, 337: 525-31, 1989). When constructed together with a therapeutic protein, an Fc domain can provide longer half-life or incorporate such functions as Fc receptor binding, protein A binding, complement fixation and perhaps even placental transfer (Capon *et al.*, *Nature*, 337: 525-31, 1989). Table I summarizes the use of certain Fc fusions known in the art, including materials and methods applicable to the production of fused huE3 α polypeptides.

Table I

Fc Fusion with Therapeutic Proteins

	Form of Fc	Fusion partner	Therapeutic implications	Reference
5	IgG1	N-terminus of CD30-L	Hodgkin's disease; anaplastic lymphoma; T-cell leukemia	U.S. Patent No. 5,480,981
	Murine Fcγ2a	IL-10	anti-inflammatory; transplant rejection	Zheng <i>et al.</i> , <i>J. Immunol.</i> , 154: 5590-600, 1995
	IgG1	TNF receptor	septic shock	Fisher <i>et al.</i> , <i>N. Engl. J. Med.</i> , 334: 1697-1702, 1996; Van Zee <i>et al.</i> , <i>J. Immunol.</i> , 156: 2221-30, 1996
10	IgG, IgA, IgM, or IgE (excluding the first domain)	TNF receptor	inflammation, autoimmune disorders	U.S. Pat. No. 5,808,029, issued September 15, 1998
15	IgG1	CD4 receptor	AIDS	Capon <i>et al.</i> , <i>Nature</i> 337: 525-31, 1989
	IgG1, IgG3	N-terminus of IL-2	anti-cancer, antiviral	Harvill <i>et al.</i> , <i>Immunotech.</i> , 1: 95-105 1995
	IgG1	C-terminus of OPG	osteoarthritis; bone density	WO 97/23614, published July 3, 1997
	IgG1	N-terminus of leptin	anti-obesity	PCT/US 97/23183, filed December 11, 1997
20	Human Ig Cγ1	CTLA-4	autoimmune disorders	Linsley, <i>J. Exp. Med.</i> , 174: 561-9, 1991

In one example, all or portion of the human IgG hinge, CH2 and CH3 regions may be fused at either the N-terminus or C-terminus of the huE3α polypeptides using methods known to the skilled artisan. In another example, a portion of a hinge regions and CH2 and CH3 regions may be fused. The resulting huE3α Fc-fusion polypeptide may be purified by use of a Protein A affinity column. Peptides and proteins fused to an Fc region have been found to exhibit a substantially greater half-life *in vivo* than the unfused counterpart. Also, a fusion to an Fc region allows for dimerization/multimerization of the fusion polypeptide. The Fc region may be a naturally occurring Fc region, or may be altered to improve certain qualities, such as therapeutic qualities, circulation time, reduce aggregation, etc.

The term "huE3 α polypeptide derivatives" refers to huE3 α I or huE3 α II polypeptides, fragments, or variants, as defined herein, that have been chemically modified. The derivatives are modified in a manner that is different from naturally occurring huE3 α , polypeptides either in the type or location of the molecules attached to the polypeptide. Derivatives may further include molecules formed by the deletion of one or more chemical groups which are naturally attached to the huE3 α polypeptide.

For example, the polypeptides may be modified by the covalent attachment of one or more polymers, including, but not limited to, water soluble polymers, N-linked or O-linked carbohydrates, sugars, phosphates, and/or other such molecules. For example, the polymer selected is typically water soluble so that the protein to which it is attached does not precipitate in an aqueous environment, such as a physiological environment. The polymer may be of any molecular weight, and may be branched or unbranched. Included within the scope of suitable polymers is a mixture of polymers. Preferably, for therapeutic use of the end-product preparation, the polymer will be pharmaceutically acceptable.

Suitable water soluble polymers or mixtures thereof include, but are not limited to, polyethylene glycol (PEG), monomethoxy-polyethylene glycol, dextran (such as low molecular weight dextran, of, for example about 6 kD), cellulose, or other carbohydrate based polymers, poly-(N-vinyl pyrrolidone) polyethylene glycol, propylene glycol homopolymers, a polypropylene oxide/ethylene oxide co-polymer, polyoxyethylated polyols (*e.g.*, glycerol) and polyvinyl alcohol. Also encompassed by the present invention are bifunctional PEG crosslinking molecules which may be used to prepare covalently attached huE3 α multimers.

For the acylation reactions, the polymer(s) selected should have a single reactive ester group. For reductive alkylation, the polymer(s) selected should have a single reactive aldehyde group. A reactive aldehyde is, for example, polyethylene glycol propionaldehyde, which is water stable, or mono C₁-C₁₀ alkoxy or aryloxy derivatives thereof (*see* U.S. Patent No. 5,252,714).

The pegylation of huE3 α polypeptides may be carried out by any of the pegylation reactions known in the art, as described for example in the following references: Francis *et al.*, *Focus on Growth Factors*, 3: 4-10, 1992; EP 0154316; EP 0401384 and U.S. Patent No. 4,179,337. Pegylation may be carried out via an acylation

reaction or an alkylation reaction with a reactive polyethylene glycol molecule (or an analogous reactive water-soluble polymer) as described herein.

Polyethylene glycol (PEG) is a water-soluble polymer suitable for use herein. As used herein, the terms "polyethylene glycol" and "PEG" are meant to encompass any of the forms of PEG that have been used to derivatize proteins, including
5 mono-(C₁-C₁₀) alkoxy- or aryloxy-polyethylene glycol.

In general, chemical derivatization may be performed under any suitable conditions used to react a biologically active substance with an activated polymer molecule. Methods for preparing pegylated huE3 α polypeptides will generally comprise
10 the steps of (a) reacting the polypeptide with polyethylene glycol (such as a reactive ester or aldehyde derivative of PEG) under conditions whereby huE3 α polypeptide becomes attached to one or more PEG groups, and (b) obtaining the reaction product(s). In general, the optimal reaction conditions for the acylation reactions will be determined based on known parameters and the desired result. For example, the larger the ratio of
15 PEG:protein, the greater the percentage of poly-pegylated product. In one embodiment, the huE3 α polypeptide derivative may have a single PEG moiety at the amino terminus. See, for example, U.S. Patent No. 5,234,784.

Generally, conditions which may be alleviated or modulated by the administration of the present huE3 α polypeptide derivative include those described
20 herein for huE3 α polypeptides. However, the huE3 α polypeptide derivative disclosed herein may have additional activities, enhanced or reduced biological activity, or other characteristics, such as increased or decreased half-life, as compared to the non-derivatized molecules.

The terms "biologically active huE3 α polypeptides", "biologically active huE3 α polypeptide fragments", "biologically active huE3 α polypeptide variants", and
25 "biologically active huE3 α polypeptide derivatives" refer to huE3 α I or huE3 α II polypeptides having at least one activity characteristic of a human E3 α ubiquitin ligase, such as the activity of the polynucleotide set forth in SEQ ID NOS: 2 or 4. In general, huE3 α polypeptides, fragments, variants, and derivatives thereof, will have at least one
30 activity characteristic of a huE3 α polypeptide such as depicted in SEQ ID NOS: 2 or 4. In addition, a huE3 α polypeptide may be active as an immunogen, that is, the polypeptide contains at least one epitope to which antibodies may be raised.

“Naturally occurring” or “native” when used in connection with biological materials such as nucleic acid molecules, polypeptides, host cells, and the like, refers to materials which are found in nature and are not manipulated by man. Similarly, “non-naturally occurring” or “non-native” as used herein refers to a material that is not found in nature or that has been structurally modified or synthesized by man.

The term “isolated polypeptide” refers to a polypeptide of the present invention that is free from at least one contaminating polypeptide that is found in its natural environment. Preferably, the isolated polypeptide is substantially free from any other contaminating mammalian polypeptides which would interfere with its therapeutic, preventative, or diagnostic use.

The term “ortholog” refers to a polypeptide that corresponds to a polypeptide identified from a different species that corresponds to huE3 α polypeptide amino acid sequence. For example, mouse and human E3 α polypeptides are considered orthologs.

The term “mature huE3 α polypeptide” refers to a polypeptide lacking a leader sequence. A mature polypeptide may also include other modifications such as proteolytic processing of the amino terminus (with or without a leader sequence) and/or the carboxy terminus, cleavage of a smaller polypeptide from a larger precursor, N-linked and/or O-linked glycosylation, and the like. An exemplary mature huE3 α polypeptide is depicted by SEQ ID NOS: 2 or 4.

The terms “effective amount” and “therapeutically effective amount” refer to the amount of a huE3 α polypeptide or huE3 α nucleic acid molecule used to support an observable level of one or more biological activities of the huE3 α polypeptides as set forth herein.

The term “selective binding agent” refers to a molecule or molecules having specificity for huE3 α molecules. Selective binding agents include antibodies, such as polyclonal antibodies, monoclonal antibodies (mAbs), chimeric antibodies, CDR-grafted antibodies, anti-idiotypic (anti-Id) antibodies to antibodies that can be labeled in soluble or bound form, as well as fragments, regions, or derivatives thereof

which are provided by known techniques, including, but not limited to enzymatic cleavage, peptide synthesis, or recombinant techniques.

As used herein, the terms, "specific" and "specificity" refer to the ability of the selective binding agents to bind to human huE3 α polypeptides. It will be appreciated, however, that the selective binding agents may also bind orthologs of huE3 α , polypeptides, that is, interspecies versions of E3 α , such as mouse and rat E3 α polypeptides. A preferred embodiment relates to antibodies that are highly specific to huE3 α polypeptides yet do not cross-react (that is, they fail to bind) with specificity to non-huE3 α polypeptides.

The term "antigen" refers to a molecule or a portion of a molecule capable of being bound by a selective binding agent, such as an antibody, which is additionally capable of inducing an animal to produce antibodies capable of binding to an epitope of that antigen. An antigen can have one or more epitopes. The specific binding reaction referred to above is meant to indicate that the antigen will react, in a highly selective manner, with its corresponding antibody and not with the multitude of other antibodies which can be evoked by other antigens.

Human E3 α polypeptides, fragments, variants, and derivatives may be used to prepare huE3 α selective binding agents using methods known in the art. Thus, antibodies and antibody fragments that bind huE3 α polypeptides are within the scope of the present invention. Antibody fragments include those portions of the antibody which bind to an epitope on the huE3 α polypeptide. Examples of such fragments include Fab and F(ab') fragments generated by enzymatic cleavage of full-length antibodies. Other binding fragments include those generated by recombinant DNA techniques, such as the expression of recombinant plasmids containing nucleic acid sequences encoding antibody variable regions. These antibodies may be, for example, polyclonal monospecific polyclonal, monoclonal, recombinant, chimeric, humanized, human, single chain, and/or bispecific.

Relatedness of Nucleic Acid Molecules and/or Polypeptides

The term "identity", as known in the art, refers to a relationship between the sequences of two or more polypeptide molecules or two or more nucleic

acid molecules, as determined by comparing the sequences. In the art, "identity" also means the degree of sequence relatedness between nucleic acid molecule or polypeptide sequences, as the case may be, as determined by the match between strings of two or more nucleotide or two or more amino acid sequences. "Identity" measures the percent of identical matches between two or more sequences with gap alignments (if any) addressed by a particular mathematical model or computer programs (*i.e.*, "algorithms").

The term "similarity" is a related concept, but in contrast to "identity", refers to a measure of similarity which includes both identical matches and conservative substitution matches. If two polypeptide sequences have, for example, 10/20 identical amino acids, and the remainder are all non-conservative substitutions, then the percent identity and similarity would both be 50%. If in the same example, there are 5 more positions where there are conservative substitutions, then the percent identity remains 50%, but the percent similarity would be 75% (15/20). Therefore, in cases where there are conservative substitutions, the degree of similarity between two polypeptide sequences will be higher than the percent identity between those two sequences.

The term "isolated nucleic acid molecule" refers to a nucleic acid molecule of the invention that (1) has been separated from at least about 50 percent of proteins, lipids, carbohydrates or other materials with which it is naturally found when total DNA is isolated from the source cells, (2) is not linked to all or a portion of a polynucleotide to which the "isolated nucleic acid molecule" is linked in nature, (3) is operably linked to a polynucleotide which it is not linked to in nature, or (4) does not occur in nature as part of a larger polynucleotide sequence. Preferably, the isolated nucleic acid molecule of the present invention is substantially free from any other contaminating nucleic acid molecule(s) or other contaminants that are found in its natural environment that would interfere with its use in polypeptide production or its therapeutic, diagnostic, prophylactic or research use.

The term "isolated polypeptide" refers to a polypeptide of the present invention that (1) has been separated from at least about 50 percent of polynucleotides, lipids, carbohydrates or other materials with which it is naturally found when isolated from the source cell, (2) is not linked (by covalent or noncovalent interaction) to all or

a portion of a polypeptide to which the "isolated polypeptide" is linked in nature, (3) is operably linked (by covalent or noncovalent interaction) to a polypeptide with which it is not linked in nature, or (4) does not occur in nature. Preferably, the isolated polypeptide is substantially free from any other contaminating polypeptides or other contaminants that are found in its natural environment that would interfere with its therapeutic, diagnostic, prophylactic or research use.

The term "conservative amino acid substitution" refers to a substitution of a native amino acid residue with a nonnative residue such that there is little or no effect on the polarity or charge of the amino acid residue at that position. For example, a conservative substitution results from the replacement of a non-polar residue in a polypeptide with any other non-polar residue. Furthermore, any native residue in the polypeptide may also be substituted with alanine, as has been previously described for "alanine scanning mutagenesis." General rules for conservative amino acid substitutions are set forth in Table II.

Table II
Amino Acid Substitutions

	Original Residues	Exemplary Substitutions	Preferred Substitutions
5	Ala	Val, Leu, Ile	Val
	Arg	Lys, Gln, Asn	Lys
	Asn	Gln	Gln
	Asp	Glu	Glu
10	Cys	Ser, Ala	Ser
	Gln	Asn	Asn
	Glu	Asp	Asp
	Gly	Pro, Ala	Ala
	His	Asn, Gln, Lys, Arg	Arg
15	Ile	Leu, Val, Met, Ala, Phe, Norleucine	Leu
	Leu	Norleucine, Ile, Val, Met, Ala, Phe	Ile
	Lys	Arg, 1,4 Diamino-butyric Acid, Gln, Asn	Arg
	Met	Leu, Phe, Ile	Leu
	Phe	Leu, Val, Ile, Ala, Tyr	Leu
20	Pro	Ala	Gly
	Ser	Thr, Ala, Cys	Thr
	Thr	Ser	Ser
	Trp	Tyr, Phe	Tyr
	Tyr	Trp, Phe, Thr, Ser	Phe
25	Val	Ile, Met, Leu, Phe, Ala, Norleucine	Leu

Conservative amino acid substitutions also encompass non-naturally occurring amino acid residues which are typically incorporated by chemical peptide synthesis rather than by synthesis in biological systems. These include peptidomimetics, and other reversed or inverted forms of amino acid moieties. It will be appreciated by those skilled in the art the nucleic acid and polypeptide molecules

described herein may be chemically synthesized as well as produced by recombinant means.

Conservative modifications to the amino acid sequence (and the corresponding modifications to the encoding nucleotides) will produce huE3 α polypeptides having functional and chemical characteristics similar to those of naturally occurring huE3 α polypeptides. In contrast, substantial modifications in the functional and/or chemical characteristics of huE3 α polypeptides may be accomplished by selecting substitutions that differ significantly in their effect on maintaining (a) the structure of the molecular backbone in the area of the substitution, for example, as a sheet or helical conformation, (b) the charge or hydrophobicity of the molecule at the target site, or (c) the bulk of the side chain. Naturally occurring residues may be divided into classes based on common side chain properties:

- 1) hydrophobic: norleucine, Met, Ala, Val, Leu, Ile;
- 2) neutral hydrophilic: Cys, Ser, Thr, Asn, Gln;
- 3) acidic: Asp, Glu;
- 4) basic: His, Lys, Arg;
- 5) residues that influence chain orientation: Gly, Pro; and
- 6) aromatic: Trp, Tyr, Phe.

Non-conservative substitutions may involve the exchange of a member of one of these classes for a member from another class. Such substituted residues may be introduced into regions of the human E3 α polypeptide that are homologous with non-human E3 α polypeptides, or into the non-homologous regions of the molecule.

Identity and similarity of related nucleic acid molecules and polypeptides can be readily calculated by known methods. Such methods include, but are not limited to, those described in *Computational Molecular Biology*, Lesk, A.M., ed., Oxford University Press, New York, 1988; *Biocomputing: Informatics and Genome Projects*, Smith, D.W., ed., Academic Press, New York, 1993; *Computer Analysis of Sequence Data*, Part 1, Griffin, A.M., and Griffin, H.G., eds., Humana Press, New Jersey, 1994; *Sequence Analysis in Molecular Biology*, von Heinje, G., Academic Press, 1987; *Sequence Analysis Primer*, Gribskov, M. and Devereux, J., eds., M.

Stockton Press, New York, 1991; and Carillo *et al.*, *SIAM J. Applied Math.*, 48: 1073, 1988.

Preferred methods to determine identity and/or similarity are designed to give the largest match between the sequences tested. Methods to determine identity and similarity are described in publicly available computer programs. Preferred computer program methods to determine identity and similarity between two sequences include, but are not limited to, the GCG program package, including GAP (Devereux *et al.*, *Nucl. Acid. Res.*, 12: 387, 1984; Genetics Computer Group, University of Wisconsin, Madison, WI), BLASTP, BLASTN, and FASTA (Altschul *et al.*, *J. Mol. Biol.*, 215: 403-410, 1990). The BLASTX program is publicly available from the National Center for Biotechnology Information (NCBI) and other sources (*BLAST Manual*, Altschul *et al.* NCB/NLM/NIH Bethesda, MD 20894; Altschul *et al.*, *supra*). The well known Smith Waterman algorithm may also be used to determine identity.

Certain alignment schemes for aligning two amino acid sequences may result in the matching of only a short region of the two sequences, and this small aligned region may have very high sequence identity even though there is no significant relationship between the two full length sequences. Accordingly, in a preferred embodiment, the selected alignment method (GAP program) will result in an alignment that spans at least 50 contiguous amino acids of the target polypeptide.

For example, using the computer algorithm GAP (Genetics Computer Group, University of Wisconsin, Madison, WI), two polypeptides for which the percent sequence identity is to be determined are aligned for optimal matching of their respective amino acids (the "matched span", as determined by the algorithm). A gap opening penalty (which is calculated as 3x the average diagonal; the "average diagonal" is the average of the diagonal of the comparison matrix being used; the "diagonal" is the score or number assigned to each perfect amino acid match by the particular comparison matrix) and a gap extension penalty (which is usually 1/10 times the gap opening penalty), as well as a comparison matrix such as PAM 250 or BLOSUM 62 are used in conjunction with the algorithm. A standard comparison matrix (see Dayhoff *et al.*, *Atlas of Protein Sequence and Structure*, vol. 5, supp.3 (1978) for the PAM 250 comparison matrix; Henikoff *et al.*, *Proc. Natl. Acad. Sci USA*, 89: 10915-10919, 1992 for the BLOSUM 62 comparison matrix) is also used by the algorithm.

Preferred parameters for a polypeptide sequence comparison include the following:

Algorithm: Needleman *et al.*, *J. Mol. Biol.*, 48, 443-453, 1970;

Comparison matrix: BLOSUM 62 from Henikoff *et al.*, *Proc. Natl. Acad. Sci.*

5 USA, 89: 10915-10919, 1992)

Gap Penalty: 12

Gap Length Penalty: 4

Threshold of Similarity: 0

10 The GAP program is useful with the above parameters. The
aforementioned parameters are the default parameters for polypeptide comparisons
(along with no penalty for end gaps) using the GAP algorithm.

Preferred parameters for nucleic acid molecule sequence comparisons include the following:

Algorithm: Needleman *et al.*, *J. Mol Biol.*, 48: 443-453, 1970;

15 Comparison matrix: matches = +10, mismatch = 0

Gap Penalty: 50

Gap Length Penalty: 3

20 The GAP program is also useful with the above parameters. The
aforementioned parameters are the default parameters for nucleic acid molecule
comparisons.

25 Other exemplary algorithms, gap opening penalties, gap extension
penalties, comparison matrices, thresholds of similarity, etc. may be used by those of
skill in the art, including those set forth in the Program Manual, Wisconsin Package,
Version 9, September, 1997. The particular choices to be made will be apparent to
those of skill in the art and will depend on the specific comparison to be made, such
as DNA to DNA, protein to protein, protein to DNA; and additionally, whether the
comparison is between given pairs of sequences (in which case GAP or BestFit are
generally preferred) or between one sequence and a large database of sequences (in
30 which case FASTA or BLASTA are preferred).

Synthesis

It will be appreciated by those skilled in the art the nucleic acid and polypeptide molecules described herein may be produced by recombinant and other means.

Nucleic Acid Molecules

Recombinant DNA methods used herein are generally those set forth in Sambrook *et al.*, *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY (1989), and/or Ausubel *et al.*, eds., *Current Protocols in Molecular Biology*, Green Publishers Inc. and Wiley and Sons, NY (1994). The present invention provides for nucleic acid molecules as described herein and methods for obtaining the molecules. Human E3 α (huE3 α) refers to the nucleotide sequence of either huE3 α I or huE3 α II. A gene or cDNA encoding a huE3 α polypeptide or fragment thereof may be obtained by hybridization screening of a genomic or cDNA library, or by PCR amplification. Where a gene encoding a huE3 α polypeptide has been identified from one species, all or a portion of that gene may be used as a probe to identify corresponding genes from other species (orthologs) or related genes from the same species (homologs). The probes or primers may be used to screen cDNA libraries from various tissue sources believed to express the huE3 α gene. In addition, part or all of a nucleic acid molecule having the sequence as set forth in SEQ ID NOS: 1 or 3 may be used to screen a genomic library to identify and isolate a gene encoding a huE3 α polypeptide. Typically, conditions of moderate or high stringency will be employed for screening to minimize the number of false positives obtained from the screen.

Nucleic acid molecules encoding huE3 α polypeptides may also be identified by expression cloning which employs the detection of positive clones based upon a property of the expressed protein. Typically, nucleic acid libraries are screened by the binding of an antibody or other binding partner (*e.g.*, receptor or ligand) to cloned proteins which are expressed and displayed on a host cell surface. The antibody or binding partner is modified with a detectable label to identify those cells expressing the desired clone.

Additional methods of predicting secondary structure include "threading" (Jones *et al.*, *Current Opin. Struct. Biol.*, 7(3):377-87 (1997); Sippl *et al.*, *Structure*, 4(1):15-9 (1996)), "profile analysis" (Bowie *et al.*, *Science*, 253:164-170 (1991); Gribskov *et al.*, *Meth. Enzym.*, 183:146-159 (1990); Gribskov *et al.*, *Proc. Nat. Acad. Sci.*, 84(13):4355-4358 (1987)), and "evolutionary linkage" (See Home, *supra*, and Brenner, *supra* 1997).

Another means of preparing a nucleic acid molecule encoding a huE3 α polypeptide, including a fragment or variant, is chemical synthesis using methods well known to the skilled artisan such as those described by Engels *et al.*, *Angew. Chem. Intl. Ed.*, 28: 716-734, 1989. These methods include, *inter alia*, the phosphotriester, phosphoramidite, and H-phosphonate methods for nucleic acid synthesis. A preferred method for such chemical synthesis is polymer-supported synthesis using standard phosphoramidite chemistry. Typically, the DNA encoding the huE3 α polypeptide will be several hundred nucleotides in length. Nucleic acids larger than about 100 nucleotides can be synthesized as several fragments using these methods. The fragments can then be ligated together to form the full length huE3 α polypeptide. Usually, the DNA fragment encoding the amino terminus of the polypeptide will have an ATG, which encodes a methionine residue. This methionine may or may not be present on the mature form of the huE3 α polypeptide, depending on whether the polypeptide produced in the host cell is designed to be secreted from that cell.

In some cases, it may be desirable to prepare nucleic acid molecules encoding huE3 α polypeptide variants. Nucleic acid molecules encoding variants may be produced using site directed mutagenesis, PCR amplification, or other appropriate methods, where the primer(s) have the desired point mutations (see Sambrook *et al.*, *supra*, and Ausubel *et al.*, *supra*, for descriptions of mutagenesis techniques). Chemical synthesis using methods described by Engels *et al.*, *supra*, may also be used to prepare such variants. Other methods known to the skilled artisan may be used as well.

In certain embodiments, nucleic acid variants contain codons which have been altered for the optimal expression of a huE3 α polypeptide in a given host cell. Particular codon alterations will depend upon the huE3 α polypeptide(s) and host cell(s) selected for expression. Such "codon optimization" can be carried out by a variety of methods, for example, by selecting codons which are preferred for use in highly

expressed genes in a given host cell. Computer algorithms which incorporate codon frequency tables such as "Ecohigh.cod" for codon preference of highly expressed bacterial genes may be used and are provided by the University of Wisconsin Package Version 9.0, Genetics Computer Group, Madison, WI. Other useful codon frequency tables include "Celegans_high.cod", "Celegans_low.cod", "Drosophila_high.cod",
5 "Human_high.cod", "Maize_high.cod", and "Yeast_high.cod".

In other embodiments, nucleic acid molecules encode huE3 α variants with conservative amino acid substitutions as described herein, huE3 α variants comprising an addition and/or a deletion of one or more N-linked or O-linked
10 glycosylation sites, huE3 α variants having deletions and/or substitutions of one or more cysteine residues, or huE3 α polypeptide fragments as described herein. In addition, nucleic acid molecules may encode any combination of huE3 α variants, fragments, and fusion polypeptides described herein.

Vectors and Host Cells

15 A nucleic acid molecule encoding a huE3 α polypeptide is inserted into an appropriate expression vector using standard ligation techniques wherein huE3 α refers to either the polypeptide sequence of huE3 α I or huE3 α II. The vector is typically selected to be functional in the particular host cell employed (*i.e.*, the vector is compatible with the host cell machinery such that amplification of the gene and/or
20 expression of the gene can occur). A nucleic acid molecule encoding a huE3 α polypeptide may be amplified/expressed in prokaryotic, yeast, insect (baculovirus systems), and/or eukaryotic host cells. Selection of the host cell will depend in part on whether a huE3 α polypeptide is to be post-translationally modified (*e.g.*, glycosylated and/or phosphorylated). If so, yeast, insect, or mammalian host cells are
25 preferable. For a review of expression vectors, see *Meth. Enz.*, v.185, D.V. Goeddel, ed. Academic Press Inc., San Diego, CA (1990).

Typically, expression vectors used in any of the host cells will contain sequences for plasmid maintenance and for cloning and expression of exogenous nucleotide sequences. Such sequences, collectively referred to as "flanking sequences"
30 in certain embodiments will typically include one or more of the following nucleotides: a promoter, one or more enhancer sequences, an origin of replication, a transcriptional termination sequence, a complete intron sequence containing a donor and acceptor

splice site, a sequence encoding a leader sequence for polypeptide secretion, a ribosome binding site, a polyadenylation sequence, a polylinker region for inserting the nucleic acid encoding the polypeptide to be expressed, and a selectable marker element. Each of these sequences is discussed below.

5 Optionally, the vector may contain a "tag"-encoding sequence, *i.e.*, an oligonucleotide sequence located at the 5' or 3' end of the huE3 α polypeptide coding sequence; the oligonucleotide molecule encodes polyHis (such as hexaHis), or another "tag" such as FLAG, HA (hemagglutinin influenza virus) or *myc* for which commercially available antibodies exist. This tag is typically fused to the polypeptide
10 upon expression of the polypeptide, and can serve as a means for affinity purification of the huE3 α polypeptide from the host cell. Affinity purification can be accomplished, for example, by column chromatography using antibodies against the tag as an affinity matrix. Optionally, the tag can subsequently be removed from the purified huE3 α polypeptide by various means such as using certain peptidases for
15 cleavage.

 Flanking sequences may be homologous (*i.e.*, from the same species and/or strain as the host cell), heterologous (*i.e.*, from a species other than the host cell species or strain), hybrid (*i.e.*, a combination of flanking sequences from more than one source), or synthetic, or the flanking sequences may be native sequences which
20 normally function to regulate huE3 α polypeptide expression. As such, the source of a flanking sequence may be any prokaryotic or eukaryotic organism, any vertebrate or invertebrate organism, or any plant, provided that the flanking sequences is functional in, and can be activated by, the host cell machinery.

 The flanking sequences useful in the vectors of this invention may be
25 obtained by any of several methods well known in the art. Typically, flanking sequences useful herein other than endogenous huE3 α gene flanking sequences will have been previously identified by mapping and/or by restriction endonuclease digestion and can thus be isolated from the proper tissue source using the appropriate restriction endonucleases. In some cases, the full nucleotide sequence of one or more
30 flanking sequence may be known. Here, the flanking sequence may be synthesized using the methods described herein for nucleic acid synthesis or cloning.

Where all or only a portion of the flanking sequence is known, it may be obtained using PCR and/or by screening a genomic library with suitable oligonucleotide and/or flanking sequence fragments from the same or another species. Where the flanking sequence is not known, a fragment of DNA containing a flanking
5 sequence may be isolated from a larger piece of DNA that may contain, for example, a coding sequence or even another gene or genes. Isolation may be accomplished by restriction endonuclease digestion to produce the proper DNA fragment followed by isolation using agarose gel purification, Qiagen® column chromatography (Chatsworth, CA), or other methods known to the skilled artisan. The selection of suitable enzymes
10 to accomplish this purpose will be readily apparent to one of ordinary skill in the art.

An origin of replication is typically a part of those prokaryotic expression vectors purchased commercially, and the origin aids in the amplification of the vector in a host cell. Amplification of the vector to a certain copy number can, in some cases, be important for the optimal expression of the huE3 α polypeptide. If the
15 vector of choice does not contain an origin of replication site, one may be chemically synthesized based on a known sequence, and ligated into the vector. For example, the origin of replication from the plasmid pBR322 (Product No. 303-3s, New England Biolabs, Beverly, MA) is suitable for most gram-negative bacteria and various origins (*e.g.*; SV40, polyoma, adenovirus, vesicular stomatitis virus (VSV) or
20 papillomaviruses such as HPV or BPV) are useful for cloning vectors in mammalian cells. Generally, the origin of replication component is not needed for mammalian expression vectors (for example, the SV40 origin is often used only because it contains the early promoter).

A transcription termination sequence is typically located 3' of the end
25 of a polypeptide coding region and serves to terminate transcription. Usually, a transcription termination sequence in prokaryotic cells is a G-C rich fragment followed by a poly T sequence. While the sequence is easily cloned from a library or even purchased commercially as part of a vector, it can also be readily synthesized using methods for nucleic acid synthesis such as those described herein.

30 A selectable marker gene element encodes a protein necessary for the survival and growth of a host cell grown in a selective culture medium. Typical selection marker genes encode proteins that (a) confer resistance to antibiotics or other

toxins, *e.g.*, ampicillin, tetracycline, or kanamycin for prokaryotic host cells, (b) complement auxotrophic deficiencies of the cell; or (c) supply critical nutrients not available from complex media. Preferred selectable markers are the kanamycin resistance gene, the ampicillin resistance gene, and the tetracycline resistance gene.

5 A neomycin resistance gene may also be used for selection in prokaryotic and eukaryotic host cells.

Other selection genes may be used to amplify the gene which will be expressed. Amplification is the process wherein genes which are in greater demand for the production of a protein critical for growth are reiterated in tandem within the

10 chromosomes of successive generations of recombinant cells. Examples of suitable selectable markers for mammalian cells include dihydrofolate reductase (DHFR) and thymidine kinase. The mammalian cell transformants are placed under selection pressure which only the transformants are uniquely adapted to survive by virtue of the selection gene present in the vector. Selection pressure is imposed by culturing the

15 transformed cells under conditions in which the concentration of selection agent in the medium is successively changed, thereby leading to the amplification of both the selection gene and the DNA that encodes huE3 α polypeptides. As a result, increased quantities of huE3 α polypeptides are synthesized from the amplified DNA.

A ribosome binding site is usually necessary for translation initiation of

20 mRNA and is characterized by a Shine-Dalgarno sequence (prokaryotes) or a Kozak sequence (eukaryotes). The element is typically located 3' to the promoter and 5' to the coding sequence of the huE3 α polypeptide to be expressed. The Shine-Dalgarno sequence is varied but is typically a polypurine (*i.e.*, having a high A-G content). Many Shine-Dalgarno sequences have been identified, each of which can be readily

25 synthesized using methods set forth above and used in a prokaryotic vector.

A leader, or signal, sequence may be used to direct a huE3 α polypeptide out of the host cell. Typically, a nucleotide sequence encoding the signal sequence is positioned in the coding region of the huE3 α nucleic acid molecule, or directly at the

30 5' end of the huE3 α polypeptide coding region. Many signal sequences have been identified, and any of those that are functional in the selected host cell may be used in conjunction with the huE3 α nucleic acid molecule. Therefore, a signal sequence may be homologous (naturally occurring) or heterologous to the huE3 α gene or cDNA.

Additionally, a signal sequence may be chemically synthesized using methods described herein. In most cases, the secretion of a huE3 α polypeptide from the host cell via the presence of a signal peptide will result in the removal of the signal peptide from the huE3 α polypeptide. The signal sequence may be a component of the vector, or it may
5 be a part of huE3 α DNA that is inserted into the vector.

Included within the scope of this invention is the use of either a nucleotide sequence encoding a native huE3 α signal sequence joined to a huE3 α polypeptide coding region or a nucleotide sequence encoding a heterologous signal sequence joined to a huE3 α polypeptide coding region. The heterologous signal
10 sequence selected should be one that is recognized and processed, *i.e.*, cleaved by a signal peptidase, by the host cell. For prokaryotic host cells that do not recognize and process the native huE3 α signal sequence, the signal sequence is substituted by a prokaryotic signal sequence selected, for example, from the group of the alkaline phosphatase, penicillinase, or heat-stable enterotoxin II leaders. For yeast secretion,
15 the native huE3 α signal sequence may be substituted by the yeast invertase, alpha factor, or acid phosphatase leaders. In mammalian cell expression the native signal sequence is satisfactory, although other mammalian signal sequences may be suitable.

In some cases, such as where glycosylation is desired in a eukaryotic host cell expression system, one may manipulate the various presequences to improve
20 glycosylation or yield. For example, one may alter the peptidase cleavage site of a particular signal peptide, or add presequences, which also may affect glycosylation. The final protein product may have, in the -1 position (relative to the first amino acid of the mature protein) one or more additional amino acids incident to expression, which may not have been totally removed. For example, the final protein product may
25 have one or two amino acid residues found in the peptidase cleavage site, attached to the N-terminus. Alternatively, use of some enzyme cleavage sites may result in a slightly truncated form of the desired huE3 α polypeptide, if the enzyme cuts at such area within the mature polypeptide.

In many cases, transcription of a nucleic acid molecule is increased by
30 the presence of one or more introns in the vector; this is particularly true where a polypeptide is produced in eukaryotic host cells, especially mammalian host cells. The introns used may be naturally occurring within the huE3 α gene, especially where the

gene used is a full length genomic sequence or a fragment thereof. Where the intron is not naturally occurring within the gene (as for most cDNAs), the intron(s) may be obtained from another source. The position of the intron with respect to flanking sequences and the huE3 α gene is generally important, as the intron must be expressed to be effective. Thus, when a huE3 α cDNA molecule is being expressed, the preferred position for the intron is 3' to the transcription start site, and 5' to the polyA transcription termination sequence. Preferably, the intron or introns will be located on one side or the other (*i.e.*, 5' or 3') of the cDNA such that it does not interrupt the coding sequence. Any intron from any source, including any viral, prokaryotic and eukaryotic (plant or animal) organisms, may be used to practice this invention, provided that it is compatible with the host cell(s) into which it is inserted. Also included herein are synthetic introns. Optionally, more than one intron may be used in the vector.

The expression and cloning vectors of the present invention will each typically contain a promoter that is recognized by the host organism and operably linked to the molecule encoding a huE3 α polypeptide. Promoters are untranscribed sequences located upstream (5') to the start codon of a structural gene (generally within about 100 to 1000 bp) that control the transcription and translation of the structural gene. Promoters are conventionally grouped into one of two classes, inducible promoters and constitutive promoters. Inducible promoters initiate increased levels of transcription from DNA under their control in response to some change in culture conditions, such as the presence or absence of a nutrient or a change in temperature. Constitutive promoters, on the other hand, initiate continual gene product production; that is, there is little or no control over gene expression. A large number of promoters, recognized by a variety of potential host cells, are well known. A suitable promoter is operably linked to the DNA encoding a huE3 α polypeptide by removing the promoter from the source DNA by restriction enzyme digestion and inserting the desired promoter sequence into the vector. The native huE3 α promoter sequence may be used to direct amplification and/or expression of huE3 α DNA. A heterologous promoter is preferred, however, if it permits greater transcription and higher yields of the expressed protein as compared to the native promoter, and if it is compatible with the host cell system that has been selected for use.

Promoters suitable for use with prokaryotic hosts include the beta-lactamase and lactose promoter systems; alkaline phosphatase, a tryptophan (trp) promoter system; and hybrid promoters such as the tac promoter. Other known bacterial promoters are also suitable. Their sequences have been published, thereby enabling one skilled in the art to ligate them to the desired DNA sequence(s), using linkers or adapters as needed to supply any useful restriction sites.

Suitable promoters for use with yeast hosts are also well known in the art. Yeast enhancers are advantageously used with yeast promoters. Suitable promoters for use with mammalian host cells are well known and include, but are not limited to, those obtained from the genomes of viruses such as polyoma virus, fowl pox virus, adenovirus (such as Adenovirus 2), bovine papilloma virus, avian sarcoma virus, cytomegalovirus (CMV), a retrovirus, hepatitis-B virus and most preferably Simian Virus 40 (SV40). Other suitable mammalian promoters include heterologous mammalian promoters, *e.g.*, heat-shock promoters and the actin promoter:

Additional promoters which may be of interest in controlling huE3 α gene transcription include, but are not limited to: the SV40 early promoter region (Bernoist and Chambon, *Nature*, 290: 304-310, 1981); the CMV promoter; the promoter contained in the 3' long terminal repeat of Rous sarcoma virus (Yamamoto *et al.*, *Cell*, 22: 787-797, 1980); the herpes thymidine kinase promoter (Wagner *et al.*, *Proc. Natl. Acad. Sci. USA*, 78: 144-1445, 1981); the regulatory sequences of the metallothioneine gene (Brinster *et al.*, *Nature*, 296: 39-42, 1982); prokaryotic expression vectors such as the beta-lactamase promoter (Villa-Kamaroff, *et al.*, *Proc. Natl. Acad. Sci. USA*, 75: 3727-3731, 1978); or the tac promoter (DeBoer, *et al.*, *Proc. Natl. Acad. Sci. USA*, 80: 21-25, 1983). Also of interest are the following animal transcriptional control regions, which exhibit tissue specificity and have been utilized in transgenic animals: the elastase I gene control region which is active in pancreatic acinar cells (Swift *et al.*, *Cell*, 38: 639-646, 1984; Ornitz *et al.*, *Cold Spring Harbor Symp. Quant. Biol.*, 50: 399-409, 1986; MacDonald, *Hepatology*, 7: 425-515, 1987); the insulin gene control region which is active in pancreatic beta cells (Hanahan, *Nature*, 315: 115-122, 1985); the immunoglobulin gene control region which is active in lymphoid cells (Grosschedl *et al.*, *Cell*, 38: 647-658 (1984); Adames *et al.*, *Nature*, 318: 533-538 (1985); Alexander *et al.*, *Mol. Cell. Biol.*, 7: 1436-1444,

1987); the mouse mammary tumor virus control region which is active in testicular, breast, lymphoid and mast cells (Leder *et al.*, *Cell*, 45: 485-495, 1986); the albumin gene control region which is active in liver (Pinkert *et al.*, *Genes and Devel.*, 1: 268-276, 1987); the alphafetoprotein gene control region which is active in liver (Krumlauf *et al.*, *Mol. Cell. Biol.*, 5: 1639-1648, 1985; Hammer *et al.*, *Science*, 235: 53-58, 1987); the alpha 1-antitrypsin gene control region which is active in the liver (Kelsey *et al.*, *Genes and Devel.*, 1: 161-171, 1987); the beta-globin gene control region which is active in myeloid cells (Mogram *et al.*, *Nature*, 315: 338-340, 1985; Kollias *et al.*, *Cell*, 46: 89-94, 1986); the myelin basic protein gene control region which is active in oligodendrocyte cells in the brain (Readhead *et al.*, *Cell*, 48: 703-712, 1987); the myosin light chain-2 gene control region which is active in skeletal muscle (Sani, *Nature*, 314: 283-286, 1985); and the gonadotropic releasing hormone gene control region which is active in the hypothalamus (Mason *et al.*, *Science*, 234: 1372-1378, 1986).

An enhancer sequence may be inserted into the vector to increase the transcription of a DNA encoding a huE3 α polypeptide of the present invention by higher eukaryotes. Enhancers are cis-acting elements of DNA, usually about 10-300 bp in length, that act on the promoter to increase its transcription. Enhancers are relatively orientation and position independent. They have been found 5' and 3' to the transcription unit. Several enhancer sequences available from mammalian genes are known (*e.g.*, globin, elastase, albumin, alpha-feto-protein and insulin). Typically, however, an enhancer from a virus will be used. The SV40 enhancer, the cytomegalovirus early promoter enhancer, the polyoma enhancer, and adenovirus enhancers are exemplary enhancing elements for the activation of eukaryotic promoters. While an enhancer may be spliced into the vector at a position 5' or 3' to huE3 α DNA, it is typically located at a-site 5' from the promoter.

Expression vectors of the invention may be constructed from a starting vector such as a commercially available vector. Such vectors may or may not contain all of the desired flanking sequences. Where one or more of the desired flanking sequences are not already present in the vector, they may be individually obtained and ligated into the vector. Methods used for obtaining each of the flanking sequences are well known to one skilled in the art.

Preferred vectors for practicing this invention are those which are compatible with bacterial, insect, and mammalian host cells. Such vectors include, *inter alia*, pCR11, pCR3, and pcDNA3.1 (Invitrogen Company, Carlsbad, CA), pBSII (Stratagene Company, La Jolla, CA), pET15 (Novagen, Madison, WI), pGEX (Pharmacia Biotech, Piscataway, NJ), pEGFP-N2 (Clontech, Palo Alto, CA), pETL (BlueBacII; Invitrogen), pDSR-alpha (PCT Publication No. WO90/14363) and pFastBacDual (Gibco/BRL, Grand Island, NY).

Additional suitable vectors include, but are not limited to, cosmids, plasmids, or modified viruses, but it will be appreciated that the vector system must be compatible with the selected host cell. Such vectors include, but are not limited to plasmids such as Bluescript[®] plasmid derivatives (a high copy number ColE1-based phagemid, Stratagene Cloning Systems Inc., La Jolla CA), PCR cloning plasmids designed for cloning Taq-amplified PCR products (*e.g.*, TOPO[™] TA Cloning[®] Kit, PCR2.1[®] plasmid derivatives, Invitrogen, Carlsbad, CA), and mammalian, yeast, or virus vectors such as a baculovirus expression system (pBacPAK plasmid derivatives, Clontech, Palo Alto, CA). The recombinant molecules can be introduced into host cells via transformation, transfection, infection, electroporation, or other known techniques.

After the vector has been constructed and a nucleic acid molecule encoding a huE3 α polypeptide has been inserted into the proper site of the vector, the completed vector may be inserted into a suitable host cell for amplification and/or polypeptide expression. Host cells may be prokaryotic host cells (such as *E. coli*) or eukaryotic host cells (such as a yeast cell, an insect cell, or a vertebrate cell). The host cell, when cultured under appropriate conditions, synthesizes a huE3 α polypeptide which can subsequently be collected from the culture medium (if the host cell secretes it into the medium) or directly from the host cell producing it (if it is not secreted). The selection of an appropriate host cell will depend upon various factors, such as desired expression levels, polypeptide modifications that are desirable or necessary for activity, such as glycosylation or phosphorylation, and ease of folding into a biologically active molecule.

A number of suitable host cells are known in the art and many are available from the American Type Culture Collection (ATCC), 10801 Univeristy Boulavard, Manassas, VA 20110-2209. Examples include, but are not limited to, mammalian cells, such as Chinese hamster ovary cells (CHO) (ATCC No. CCL61) CHO DHFR-cells (Urlaub *et al.*, *Proc. Natl. Acad. Sci. USA*, 97: 4216-4220, 1980), human

embryonic kidney (HEK) 293 or 293T cells (ATCC No. CRL1573), or 3T3 cells (ATCC No. CCL92). The selection of suitable mammalian host cells and methods for transformation, culture, amplification, screening and product production and purification are known in the art. Other suitable mammalian cell lines, are the monkey COS-1 (ATCC No. CRL1650) and COS-7 cell lines (ATCC No. CRL1651), and the CV-1 cell line (ATCC No. CCL70). Further exemplary mammalian host cells include primate cell lines and rodent cell lines, including transformed cell lines. Normal diploid cells, cell strains derived from *in vitro* culture of primary tissue, as well as primary explants, are also suitable. Candidate cells may be genotypically deficient in the selection gene, or may contain a dominantly acting selection gene. Other suitable mammalian cell lines include but are not limited to, mouse neuroblastoma N2A cells, HeLa, mouse L-929 cells, 3T3 lines derived from Swiss, Balb-c or NIH mice, BHK or HaK hamster cell lines, which are available from the American Type Culture Collection, Manassas, VA. Each of these cell lines is known by and available to those skilled in the art of protein expression.

Similarly useful as host cells suitable for the present invention are bacterial cells. For example, the various strains of *E. coli* (e.g., HB101, (ATCC No. 33694) DH5 α , DH10, and MC1061 (ATCC No. 53338)) are well-known as host cells in the field of biotechnology. Various strains of *B. subtilis*, *Pseudomonas spp.*, other *Bacillus spp.*, *Streptomyces spp.*, and the like may also be employed in this method.

Many strains of yeast cells known to those skilled in the art are also available as host cells for the expression of the polypeptides of the present invention. Preferred yeast cells include, for example, *Saccharomyces cerevisiae* and *Pichia pastoris*.

Additionally, where desired, insect cell systems may be utilized in the methods of the present invention. Such systems are described for example in Kitts *et al.*, *Biotechniques*, 14: 810-817 (1993); Lucklow, *Curr. Opin. Biotechnol.*, 4: 564-572, 1993; and Lucklow *et al. J. Virol.*, 67: 4566-4579, 1993. Preferred insect cells are Sf-9 and Hi5 (Invitrogen, Carlsbad, CA).

The transformation of an expression vector for a huE3 α polypeptide into a selected host cell may be accomplished by well known methods including methods such as transfection, infection, calcium chloride, electroporation, microinjection, lipofection or the DEAE-dextran method or other known techniques. The method selected will in part be a function of the type of host cell to be used. These methods and

other suitable methods are well known to the skilled artisan, and are set forth, for example, in Sambrook *et al.*, *supra*.

One may also use transgenic animals to express glycosylated huE3 α polypeptides. For example, one may use a transgenic milk-producing animal (a cow or goat, for example) and obtain the present glycosylated polypeptide in the animal milk. One may also use plants to produce huE3 α polypeptides, however, in general, the glycosylation occurring in plants is different from that produced in mammalian cells, and may result in a glycosylated product which is not suitable for human therapeutic use.

Polypeptide Production

Host cells comprising a huE3 α expression vector may be cultured using standard media well known to the skilled artisan. The huE3 α expression vector refers a vector which expresses either huE3 α I or huE3 α II. The media will usually contain all nutrients necessary for the growth and survival of the cells. Suitable media for culturing *E. coli* cells include, for example, Luria Broth (LB) and/or Terrific Broth (TB). Suitable media for culturing eukaryotic cells are, Roswell Park Memorial Institute medium 1640 (RPMI 1640), Minimal Essential Medium (MEM), and/or Dulbecco's Modified Eagle Medium (DMEM), all of which may be supplemented with serum and/or growth factors as indicated by the particular cell line being cultured. A suitable medium for insect cultures is Grace's medium supplemented with yeastolate, lactalbumin hydrolysate, and/or fetal calf serum as necessary.

Typically, an antibiotic or other compound useful for selective growth of transformed cells is added as a supplement to the media. The compound to be used will be dictated by the selectable marker element present on the plasmid with which the host cell was transformed. For example, where the selectable marker element is kanamycin resistance, the compound added to the culture medium will be kanamycin. Other compounds for selective growth include ampicillin, tetracycline, and neomycin.

The amount of a huE3 α polypeptide produced by a host cell can be evaluated using standard methods known in the art. Such methods include, without limitation, Western blot analysis, SDS-polyacrylamide gel electrophoresis, non-denaturing gel electrophoresis, High Performance Liquid Chromatography (HPLC) separation, immunoprecipitation, and/or activity assays such as DNA binding gel shift assays.

If a huE3 α polypeptide has been designed to be secreted from the host cells, the majority of polypeptide may be found in the cell culture medium. If however, the huE3 α polypeptide is not secreted from the host cells, it will be present in the cytoplasm and/or the nucleus (for eukaryotic host cells) or in the cytosol (for bacterial host cells).

For a huE3 α polypeptide situated in the host cell cytoplasm and/or nucleus, the host cells are typically first disrupted mechanically or with a detergent to release the intracellular contents into a buffered solution. Human E3 α polypeptide can then be isolated from this solution.

The purification of a huE3 α polypeptide from solution can be accomplished using a variety of techniques. If the polypeptide has been synthesized such that it contains a tag such as Hexahistidine (huE3 α polypeptide/hexaHis) or other small peptide such as FLAG (Eastman Kodak Co., New Haven, CT) or *myc* (Invitrogen, Carlsbad, CA) at either its carboxyl or amino terminus, it may essentially be purified in a one-step process by passing the solution through an affinity column where the column matrix has a high affinity for the tag or for the polypeptide directly (*i.e.*, a monoclonal antibody specifically recognizing and binding to the huE3 α polypeptide). For example, polyhistidine binds with great affinity and specificity to nickel, thus an affinity column of nickel (such as the Qiagen[®] nickel columns) can be used for purification of huE3 α polypeptide/polyHis. See for example, Ausubel *et al.*, eds., *Current Protocols in Molecular Biology*, Section 10.11.8, John Wiley & Sons, New York (1993).

Where a huE3 α polypeptide is prepared without a tag attached, and no antibodies are available, other well known procedures for purification can be used. Such procedures include, without limitation, ion exchange chromatography, molecular sieve chromatography, High Performance Liquid Chromatography (HPLC), native gel electrophoresis in combination with gel elution, and preparative isoelectric focusing ("Isoprime" machine/technique, Hoefer Scientific, San Francisco, CA). In some cases, two or more of these techniques may be combined to achieve increased purity.

If a huE3 α polypeptide is produced intracellularly, the intracellular material (including inclusion bodies for gram-negative bacteria) can be extracted from the host cell using any standard technique known to the skilled artisan. For example, the host cells can be lysed to release the contents of the periplasm/cytoplasm by French press, homogenization, and/or sonication followed by centrifugation.

If a huE3 α polypeptide has formed inclusion bodies in the cytosol, the inclusion bodies can often bind to the inner and/or outer cellular membranes and thus will be found primarily in the pellet material after centrifugation. The pellet material can then be treated at pH extremes or with chaotropic agent such as a detergent, guanidine, 5 guanidine derivatives, urea, or urea derivatives in the presence of a reducing agent such as dithiothreitol at alkaline pH or tris carboxyethyl phosphine at acid pH to release, break apart, and solubilize the inclusion bodies. The solubilized huE3 α polypeptide can then be analyzed using gel electrophoresis, immunoprecipitation or the like. If it is desired to isolate the huE3 α polypeptide, isolation may be accomplished using standard methods 10 such as those described herein and in Marston *et al.*, *Meth. Enz.*, 182: 264-275 1990.

In some cases, a huE3 α polypeptide may not be biologically active upon isolation. Various methods for "refolding" or converting the polypeptide to its tertiary structure and generating disulfide linkages, can be used to restore biological activity. Such methods include exposing the solubilized polypeptide to a pH usually above 7 and 15 in the presence of a particular concentration of a chaotrope. The selection of chaotrope is very similar to the choices used for inclusion body solubilization, but usually the chaotrope is used at a lower concentration and is not necessarily the same as chaotropes used for the solubilization. In most cases the refolding/oxidation solution will also contain a reducing agent or the reducing agent plus its oxidized form in a specific ratio 20 to generate a particular redox potential allowing for disulfide shuffling to occur in the formation of the protein's cysteine bridge(s). Some of the commonly used redox couples include cysteine/cystamine, glutathione (GSH)/dithiobis GSH, cupric chloride, dithiothreitol(DTT)/ dithiane DTT, and 2-2mercaptoethanol(β ME)/dithi(β ME). A cosolvent may be used to increase the efficiency of the refolding, and the more common 25 reagents used for this purpose include glycerol, polyethylene glycol of various molecular weights, arginine and the like.

If inclusion bodies are not formed to a significant degree upon expression of a huE3 α polypeptide, then the polypeptide will be found primarily in the supernatant after centrifugation of the cell homogenate. The polypeptide may be further isolated 30 from the supernatant using methods such as those described herein.

In situations where it is preferable to partially or completely purify a huE3 α polypeptide such that it is partially or substantially free of contaminants, standard methods known to those skilled in the art may be used. Such methods include, without limitation, separation by electrophoresis followed by electroelution, various types of

chromatography (affinity, immunoaffinity, molecular sieve, and/or ion exchange). and/or high pressure liquid chromatography. In some cases, it may be preferable to use more than one of these methods for complete purification.

Human E3 α polypeptides, including fragments, variants, and/or derivatives thereof may also be prepared by chemical synthesis methods (such as solid phase peptide synthesis) using techniques known in the art, such as those set forth by Merrifield *et al.*, *J. Am. Chem. Soc.*, 85 :2149, 1963, Houghten *et al.*, *Proc Natl Acad. Sci. USA*, 82: 5132 1985, and Stewart and Young, *Solid Phase Peptide Synthesis*, Pierce Chemical Co., Rockford, IL (1984). Such polypeptides may be synthesized with or without a methionine on the amino terminus. Chemically synthesized huE3 α polypeptides may be oxidized using methods set forth in these references to form disulfide bridges. Chemically synthesized huE3 α polypeptides are expected to have comparable biological activity to the corresponding huE3 α polypeptides produced recombinantly or purified from natural sources, and thus may be used interchangeably with a recombinant or natural huE3 α polypeptide.

Another means of obtaining a huE3 α polypeptide is via purification from biological samples such as source tissues and/or fluids in which the huE3 α polypeptide is naturally found. Such purification can be conducted using methods for protein purification as described herein. The presence of the huE3 α polypeptide during purification may be monitored using, for example, using an antibody prepared against recombinantly produced huE3 α polypeptide or peptide fragments thereof.

A number of additional methods for producing nucleic acids and polypeptides are known in the art, and the methods can be used to produce polypeptides having specificity for h2520-109. See for example, Roberts *et al.*, *Proc. Natl. Acad. Sci U.S.A.*, 94:12297-12303, 1997, which describes the production of fusion proteins between an mRNA and its encoded peptide. See also Roberts, R., *Curr. Opin. Chem. Biol.*, 3:268-273, 1999. Additionally, U.S. Patent No. 5,824,469 describes methods of obtaining oligonucleotides capable of carrying out a specific biological function. The procedure involves generating a heterogeneous pool of oligonucleotides, each having a 5' randomized sequence, a central preselected sequence, and a 3' randomized sequence. The resulting heterogeneous pool is introduced into a population of cells that do not exhibit the desired biological function. Subpopulations of the cells are then screened for those which exhibit a predetermined biological function. From that subpopulation, oligonucleotides capable of carrying out the desired biological function are isolated.

U.S. Patent Nos. 5,763,192; 5,814,476; 5,723,323; and 5,817,483 describe processes for producing peptides or polypeptides. This is done by producing stochastic genes or fragments thereof, and then introducing these genes into host cells which produce one or more proteins encoded by the stochastic genes. The host cells are then
5 screened to identify those clones producing peptides or polypeptides having the desired activity.

Another method for producing peptides or polypeptides is described in PCT/US98/20094 (WO99/15650) filed by Athersys, Inc. Known as "Random Activation of Gene Expression for Gene Discovery" (RAGE-GD), the process involves the
10 activation of endogenous gene expression or over-expression of a gene by in situ recombination methods. For example, expression of an endogenous gene is activated or increased by integrating a regulatory sequence into the target cell which is capable of activating expression of the gene by non-homologous or illegitimate recombination. The target DNA is first subjected to radiation, and a genetic promoter inserted. The promoter
15 eventually locates a break at the front of a gene, initiating transcription of the gene. This results in expression of the desired peptide or polypeptide.

It will be appreciated that these methods can also be used to create comprehensive IL-17 like protein expression libraries, which can subsequently be used for high throughput phenotypic screening in a variety of assays, such as biochemical
20 assays, cellular assays, and whole organism assays (*e.g.*, plant, mouse, etc.).

Chemical Derivatives

Chemically modified derivatives of the h2520-109 polypeptides may be prepared by one skilled in the art, given the disclosures set forth herein below. h2520-
25 109 polypeptide derivatives are modified in a manner that is different, either in the type or location of the molecules naturally attached to the polypeptide. Derivatives may include molecules formed by the deletion of one or more naturally-attached chemical groups. The polypeptide comprising the amino acid sequence of SEQ ID NO: 2, or a h2520-109 polypeptide variant, may be modified by the covalent attachment of one or
30 more polymers. For example, the polymer selected is typically water soluble so that the protein to which it is attached does not precipitate in an aqueous environment, such as a physiological environment. Included within the scope of suitable polymers is a mixture of polymers. Preferably, for therapeutic use of the end-product preparation, the polymer will be pharmaceutically acceptable.

The polymers each may be of any molecular weight and may be branched or unbranched. The polymers each typically have an average molecular weight of between about 2 kDa to about 100 kDa (the term "about" indicating that in preparations of a water soluble polymer, some molecules will weigh more, some less, than the stated molecular weight). The average molecular weight of each polymer is preferably between about 5 kDa and about 50 kDa, more preferably between about 12 kDa and about 40 kDa and most preferably between about 20 kDa to about 35 kDa. Suitable water soluble polymers or mixtures thereof include, but are not limited to, N-linked or O-linked carbohydrates; sugars; phosphates; polyethylene glycol (PEG) (including the forms of PEG that have been used to derivatize proteins, including mono-(C1-C10) alkoxy- or aryloxy-polyethylene glycol), monomethoxy-polyethylene glycol; dextran (such as low molecular weight dextran of, for example about 6 kD;; cellulose, or other carbohydrate-based polymers, poly-(N-vinyl pyrrolidone)polyethylene glycol, propylene glycol homopolymers, a polypropylene oxide/ethylene oxide co-polymer, polyoxyethylated polyols (e.g., glycerol) and polyvinyl alcohol. Also encompassed by the present invention are bifunctional crosslinking molecules which may be used to prepare covalently attached multimers of the polypeptide comprising the amino acid sequence of SEQ ID NO: 2 or a h2520-109 polypeptide variant.

In general, chemical derivatization may be performed under any suitable condition used to react a protein with an activated polymer molecule. Methods for preparing chemical derivatives of polypeptides will generally comprise the steps of (a) reacting the polypeptide with the activated polymer molecule (such as a reactive ester or aldehyde derivative of the polymer molecule) under conditions whereby the polypeptide comprising the amino acid sequence of SEQ ID NO: 2, or a h2520-109 polypeptide variant becomes attached to one or more polymer molecules, and (b) obtaining the reaction product(s). The optimal reaction conditions will be determined based on known parameters and the desired result. For example, the larger the ratio of polymer molecules:protein, the greater the percentage of attached polymer molecule. In one embodiment, the h2520-109 polypeptide derivative may have a single polymer molecule moiety at the amino terminus. (See, for example, U.S. Patent No. 5,234,784). The pegylation of the polypeptide may be specifically carried out by any of the pegylation reactions known in the art, as described for example in the following references: Francis *et al.*, *Focus on Growth Factors*, 3:4-10 (1992); EP 0154316; EP 0401384 and U.S. Patent No. 4,179,337. For example, pegylation may be carried out via

an acylation reaction or an alkylation reaction with a reactive polyethylene glycol molecule (or an analogous reactive water-soluble polymer) as described herein. For the acylation reactions, the polymer(s) selected should have a single reactive ester group. For reductive alkylation, the polymer(s) selected should have a single reactive aldehyde group. A reactive aldehyde is, for example, polyethylene glycol propionaldehyde, which is water stable, or mono C1-C10 alkoxy or aryloxy derivatives thereof (see U.S. Patent No. 5,252,714).

In another embodiment, h2520-109 polypeptides may be chemically coupled to biotin, and the biotin/h2520-109 polypeptide molecules which are conjugated are then allowed to bind to avidin, resulting in tetravalent avidin/biotin/h2520-109 polypeptide molecules. h2520-109 polypeptides may also be covalently coupled to dinitrophenol (DNP) or trinitrophenol (TNP) and the resulting conjugates precipitated with anti-DNP or anti-TNP-IgM to form decameric conjugates with a valency of 10.

Generally, conditions which may be alleviated or modulated by the administration of the present h2520-109 polypeptide derivatives include those described herein for h2520-109 polypeptides. However, the h2520-109 polypeptide derivatives disclosed herein may have additional activities, enhanced or reduced biological activity, or other characteristics, such as increased or decreased half-life, as compared to the non-derivatized molecules.

Selective Binding Agents

As used herein, the term "selective binding agent" refers to a molecule which has specificity for one or more huE3 α polypeptides. Suitable selective binding agents include, but are not limited to, antibodies and derivatives thereof, polypeptides, and small molecules. Suitable selective binding agents may be prepared using methods known in the art. An exemplary huE3 α polypeptide selective binding agent of the present invention is capable of binding a certain portion of the huE3 α polypeptide thereby inhibiting the binding of a cofactor to the huE3 α polypeptide.

Human E3 α polypeptides, fragments, variants, and derivatives may be used to prepare selective binding agents (such as antibodies) using methods known in the art; wherein huE3 α polypeptide refers to either huE3 α I or huE3 α II polypeptide. Thus, selective binding agents such as antibodies and antibody fragments that bind huE3 α polypeptides are within the scope of the present invention. The antibodies may

be polyclonal, monospecific polyclonal, monoclonal, recombinant, chimeric, humanized, human, single chain, and/or bispecific.

5 Polyclonal antibodies directed toward a huE3 α polypeptide generally are raised in animals (*e.g.*, rabbits or mice) by multiple subcutaneous or intraperitoneal injections of huE3 α polypeptide and an adjuvant. It may be useful to conjugate a huE3 α polypeptide, or a variant, fragment, or derivative thereof to a carrier protein that is immunogenic in the species to be immunized, such as keyhole limpet heocyanin, serum, albumin, bovine thyroglobulin, or soybean trypsin inhibitor. Also, aggregating agents such as alum are used to enhance the immune response. After immunization, the animals
10 are bled and the serum is assayed for anti-huE3 α antibody titer.

Monoclonal antibodies directed toward huE3 α polypeptides are produced using any method which provides for the production of antibody molecules by continuous cell lines in culture. Examples of suitable methods for preparing monoclonal antibodies include the hybridoma methods of Kohler *et al.*, *Nature*, 256: 495-497, 1975
15 and the human B-cell hybridoma method, Kozbor, *J. Immunol.*, 133: 3001, 1984; Brodeur *et al.*, *Monoclonal Antibody Production Techniques and Applications*, pp. 51-63 (Marcel Dekker, Inc., New York, 1987). Also provided by the invention are hybridoma cell lines which produce monoclonal antibodies reactive with huE3 α polypeptides.

Monoclonal antibodies of the invention may be modified for use as
20 therapeutics. One embodiment is a "chimeric" antibody in which a portion of the heavy and/or light chain is identical with or homologous to a corresponding sequence in antibodies derived from a particular species or belonging to a particular antibody class or subclass, while the remainder of the chain(s) is identical with or homologous to a corresponding sequence in antibodies derived from another species or belonging to
25 another antibody class or subclass. Also included are fragments of such antibodies, so long as they exhibit the desired biological activity. See, U.S. Patent No. 4,816,567; Morrison *et al.*, *Proc. Natl. Acad. Sci.*, 81: 6851-6855 (1985).

In another embodiment, a monoclonal antibody of the invention is a
30 "humanized" antibody. Methods for humanizing non-human antibodies are well known in the art. Generally, a humanized antibody has one or more amino acid residues introduced into it from a source which is non-human. Humanization can be performed following methods known in the art (Jones *et al.*, *Nature* 321: 522-525, 1986; Riechmann *et al.*, *Nature*, 332: 323-327 (1988); Verhoeyen *et al.*, *Science* 239:1534-

1536, 1988), by substituting rodent complementarity-determining regions (CDRs) for the corresponding regions of a human antibody.

Also encompassed by the invention are human antibodies which bind huE3 α polypeptides, fragments, variants and/or derivatives. Such antibodies are produced by immunization with a huE3 α antigen (*i.e.*, having at least 6 contiguous amino acids), optionally conjugated to a carrier, of transgenic animals (*e.g.*, mice) that are capable of producing a repertoire of human antibodies in the absence of endogenous immunoglobulin production. *See*, for example, Jakobovits *et al.*, *Proc. Natl. Acad. Sci.*, 90: 2551-2555, 1993; Jakobovits *et al.*, *Nature* 362: 255-258, 1993; Bruggermann *et al.*, *Year in Immuno.*, 7: 33 (1993). In one method, such transgenic animals are produced by incapacitating the endogenous loci encoding the heavy and light immunoglobulin chains therein, and inserting loci encoding human heavy and light chain proteins into the genome thereof. Partially modified animals, that is those having less than the full complement of modifications, are then cross-bred to obtain an animal having all of the desired immune system modifications. When administered an immunogen, these transgenic animals produce antibodies with human variable regions, including human (rather than *e.g.*, murine) antibodies which are immunospecific for these antigens. *See* PCT application Nos. PCT/US96/05928 and PCT/US93/06926. Additional methods are described in U.S. Patent No. 5,545,807, PCT application Nos. PCT/US91/245, PCT/GB89/01207, and in EP 546073B1 and EP 546073A1.

Human antibodies can also be produced from phage-display libraries (Hoogenboom *et al.*, *J. Mol. Biol.* 227: 381 1991; Marks *et al.*, *J. Mol. Biol.* 222: 581, 1991). These processes mimic immune selection through the display of antibody repertoires on the surface of filamentous bacteriophage, and subsequent selection of phage by their binding to an antigen of choice. One such technique is described in PCT Application WO99/10494, filed in the name of Adams *et al.*, which describes the isolation of high affinity and functional agonistic antibodies for MPL- and msk-receptors using such an approach.

Chimeric, CDR grafted, and humanized antibodies are typically produced by recombinant methods. Nucleic acids encoding the antibodies are introduced into host cells and expressed using materials and procedures described herein. In a preferred embodiment, the antibodies are produced in mammalian host cells, such as CHO cells. Human antibodies may be produced by the expression of recombinant DNA in host cells or by expression in hybridoma cells as described herein.

For diagnostic applications, in certain embodiments, anti-huE3 α antibodies typically will be labeled with a detectable moiety. The detectable moiety can be any one which is capable of producing, either directly or indirectly, a detectable signal. For example, the detectable moiety may be a radioisotope, such as ^3H , ^{14}C , ^{32}P , ^{35}S , or ^{125}I , a fluorescent or chemiluminescent compound, such as fluorescein isothiocyanate, rhodamine, or luciferin; or an enzyme, such as alkaline phosphatase, β -galactosidase, or horseradish peroxidase (Bayer *et al.*, *Meth. Enz.*, 184: 138-163 1990).

The anti-huE3 α antibodies of the invention may be employed in any known assay method, such as competitive binding assays, direct and indirect sandwich assays, and immunoprecipitation assays (Sola, *Monoclonal Antibodies: A Manual of Techniques*, pp. 147-158 (CRC Press, Inc., 1987)) for the detection and quantitation of huE3 α polypeptides. The antibodies will bind huE3 α polypeptides with an affinity which is appropriate for the assay method being employed.

Competitive binding assays rely on the ability of a labeled standard (*e.g.*, a huE3 α polypeptide, or an immunologically reactive portion thereof) to compete with the test sample analyte (a huE3 α polypeptide) for binding with a limited amount of anti-huE3 α antibody. The amount of a huE3 α polypeptide in the test sample is inversely proportional to the amount of standard that becomes bound to the antibodies. To facilitate determining the amount of standard that becomes bound, the antibodies typically are insolubilized before or after the competition, so that the standard and analyte that are bound to the antibodies may conveniently be separated from the standard and analyte which remain unbound.

Sandwich assays typically involve the use of two antibodies, each capable of binding to a different immunogenic portion, or epitope, of the protein to be detected and/or quantitated. In a sandwich assay, the test sample analyte is typically bound by a first antibody which is immobilized on a solid support, and thereafter a second antibody binds to the analyte, thus forming an insoluble three part complex. *See, e.g.*, U.S. Patent No. 4,376,110. The second antibody may itself be labeled with a detectable moiety (direct sandwich assays) or may be measured using an anti-immunoglobulin antibody that is labeled with a detectable moiety (indirect sandwich assays). For example, one type of sandwich assay is an enzyme-linked immunosorbent assay (ELISA), in which case the detectable moiety is an enzyme.

The selective binding agents, including anti-h2520-109 antibodies, are also useful for *in vivo* imaging. An antibody labeled with a detectable moiety may be

administered to an animal, preferably into the bloodstream, and the presence and location of the labeled antibody in the host is assayed. The antibody may be labeled with any moiety that is detectable in an animal, whether by nuclear magnetic resonance, radiology, or other detection means known in the art.

5 Selective binding agents of the invention, including anti-h2520-109 antibodies, may be used as therapeutics. These therapeutic agents are generally agonists or antagonists, in that they either enhance or reduce, respectively, at least one of the biological activities of a h2520-109 polypeptide. In one embodiment, antagonist antibodies of the invention are antibodies or binding fragments thereof which are capable
10 of specifically binding to a h2520-109 polypeptide and which are capable of inhibiting or eliminating the functional activity of a h2520-109 polypeptide *in vivo* or *in vitro*. In preferred embodiments, the selective binding agent, *e.g.*, an antagonist antibody will inhibit the functional activity of a h2520-109 polypeptide by at least about 50%, and preferably by at least about 80%. In another embodiment, the selective binding agent
15 may be an antibody that is capable of interacting with a h2520-109 binding partner (a ligand, co-factor, or receptor) thereby inhibiting or eliminating h2520-109 activity *in vitro* or *in vivo*. Selective binding agents, including agonist and antagonist anti-h2520-109 antibodies are identified by screening assays which are well known in the art.

20 The invention also relates to a kit comprising huE3 α selective binding agents (such as antibodies) and other reagents useful for detecting huE3 α levels in biological samples. Such reagents may include a secondary activity, a detectable label, blocking serum, positive and negative control samples, and detection reagents.

Genetically Engineered Non-Human Animals

25 Additionally included within the scope of the present invention are non-human animals such as mice, rats, or other rodents, rabbits, goats, or sheep, or other farm animals, in which the gene (or genes) encoding a native E3 α ubiquitin ligase polypeptide (such as E3 α I or E3 α II) has (have) been disrupted ("knocked out") such that the level of expression of this gene or genes is (are) significantly decreased or completely
30 abolished. Such animals may be prepared using techniques and methods such as those described in U.S. Patent No. 5,557,032.

 The present invention further includes non-human animals such as mice, rats, or other rodents, rabbits, goats, or sheep, or other farm animals, in which either the native form of the E3 α ubiquitin ligase polypeptide gene(s) for that animal or a

heterologous E3 α ubiquitin ligase polypeptide gene(s) is (are) over expressed by the animal, thereby creating a "transgenic" animal. Such transgenic animals may be prepared using well known methods such as those described in U.S. Patent No 5,489,743 and PCT application No. WO94/28122.

5 The present invention further includes non-human animals in which the promoter for one or more of the E3 α ubiquitin ligase polypeptides of the present invention is either activated or inactivated (*e.g.*, by using homologous recombination methods) to alter the level of expression of one or more of the native E3 α ubiquitin ligase polypeptides.

10 These non-human animals may be used for drug candidate screening. In such screening, the impact of a drug candidate on the animal may be measured. For example, drug candidates may decrease or increase the expression of the E3 α ubiquitin ligase polypeptide gene. In certain embodiments, the amount of E3 α ubiquitin ligase polypeptide, or a fragment(s), that is produced may be measured after the exposure of
15 the animal to the drug candidate. Additionally, in certain embodiments, one may detect the actual impact of the drug candidate on the animal. For example, the overexpression of a particular gene may result in, or be associated with, a disease or pathological condition. In such cases, one may test a drug candidate's ability to decrease expression of the gene or its ability to prevent or inhibit a pathological condition. In other
20 examples, the production of a particular metabolic product such as a fragment of a polypeptide, may result in, or be associated with, a disease or pathological condition. In such cases, one may test a drug candidate's ability to decrease the production of such a metabolic product or its ability to prevent or inhibit a pathological condition.

25 Microarray

 It will be appreciated that DNA microarray technology can be utilized in accordance with the present invention. DNA microarrays are miniature, high density arrays of nucleic acids positioned on a solid support, such as glass. Each cell or element within the array has numerous copies of a single species of DNA which acts as a target
30 for hybridization for its cognate mRNA. In expression profiling using DNA microarray technology, mRNA is first extracted from a cell or tissue sample and then converted enzymatically to fluorescently labeled cDNA. This material is hybridized to the microarray and unbound cDNA is removed by washing. The expression of discrete genes represented on the array is then visualized by quantitating the amount of labeled

cDNA which is specifically bound to each target DNA. In this way, the expression of thousands of genes can be quantitated in a high throughput, parallel manner from a single sample of biological material.

5 This high throughput expression profiling has a broad range of applications with respect to the h2520-109 molecules of the invention, including, but not limited to: the identification and validation of h2520-109 disease-related genes as targets for therapeutics; molecular toxicology of h2520-109 molecules and inhibitors thereof; stratification of populations and generation of surrogate markers for clinical trials; and the enhancement of an h2520-109-related small molecule drug discovery by aiding in
10 the identification of selective compounds in high throughput screens (HTS).

Assaying for other modulators of huE3 α polypeptide activity

In some situations, it may be desirable to identify molecules that are modulators, *i.e.*, antagonists and agonists, of the activity of huE3 α polypeptide.

15 Natural or synthetic molecules that modulate huE3 α polypeptides can be identified using one or more screening assays, such as those described herein. Such molecules may be administered either in an *ex vivo* manner, or in an *in vivo* manner by injection, or by oral delivery, implantation device, or the like.

The following definition is used herein for describing the assays. "Test molecule(s)" refers to the molecule(s) that is/are under evaluation for the ability to
20 modulate (*i.e.*, increase or decrease) the activity of a huE3 α polypeptide. Most commonly, a test molecule will interact directly with a huE3 α polypeptide. However, it is also contemplated that a test molecule may also modulate huE3 α polypeptide activity indirectly, such as by affecting huE3 α gene expression, or by binding to a huE3 α binding partner (*e.g.*, receptor, co-factor or ligand). In one embodiment, a test molecule
25 will bind to a huE3 α polypeptide with an affinity constant of at least about 10^{-6} M, preferably about 10^{-8} M, more preferably about 10^{-9} M, and even more preferably about 10^{-10} M.

30 Methods for identifying compounds which interact with huE3 α polypeptides are encompassed by the present invention. In certain embodiments, a huE3 α polypeptide is incubated with a test molecule under conditions which permit the interaction of the test molecule with a huE3 α polypeptide, and the extent of the interaction can be measured. The test molecule(s) can be screened in a substantially purified form or in a crude mixture. Test molecule(s) can be nucleic acid molecules,

proteins, peptides, carbohydrates, lipids, or small molecular weight organic or inorganic compounds. Once a set of has been identified as interacting with a huE3 α polypeptide, the molecules may be further evaluated for their ability to increase or decrease huE3 α activity.

5 The measurement of the interaction of test molecules with huE3 α polypeptides may be carried out in several formats, including cell-based binding assays, membrane binding assays, solution-phase assays and immunoassays. In general, test molecules are incubated with a huE3 α polypeptide for a specified period of time, and huE3 α activity is determined by one or more assays described herein for measuring
10 biological activity.

 The interaction of test molecules with huE3 α polypeptides may also be assayed directly using polyclonal or monoclonal antibodies in an immunoassay. Alternatively, modified forms of huE3 α polypeptides containing epitope tags as described herein may be used in solution and immunoassays.

15 In certain embodiments, a huE3 α polypeptide agonist or antagonist may be a protein, peptide, carbohydrate, lipid, or small molecular weight molecule which interacts with huE3 α polypeptide to regulate its activity. Molecules which regulate huE3 α polypeptide expression include nucleic acids which are complementary to nucleic acids encoding a huE3 α polypeptide, or are complementary to nucleic acids sequences
20 which direct or control the expression of huE3 α polypeptide, and which act as antisense regulators of expression.

 Once a set of test molecules has been identified as interacting with a h2520-109 polypeptide, the molecules may be further evaluated for their ability to increase or decrease h2520-109 polypeptide activity. The measurement of the
25 interaction of test molecules with h2520-109 polypeptides may be carried out in several formats, including cell-based binding assays, membrane binding assays, solution-phase assays and immunoassays. In general, test molecules are incubated with a h2520-109 polypeptide for a specified period of time, and h2520-109 polypeptide activity is determined by one or more assays for measuring biological activity.

30 The interaction of test molecules with h2520-109 polypeptides may also be assayed directly using polyclonal or monoclonal antibodies in an immunoassay. Alternatively, modified forms of h2520-109 polypeptides containing epitope tags as described herein may be used in immunoassays.

In the event that h2520-109 polypeptides display biological activity through an interaction with a binding partner (e.g., a receptor, a ligand or a co-factor), a variety of *in vitro* assays may be used to measure the binding of a h2520-109 polypeptide to the corresponding binding partner (such as a selective binding agent, receptor, ligand, or co-factor). These assays may be used to screen test molecules for their ability to increase or decrease the rate and/or the extent of binding of a h2520-109 polypeptide to its binding partner. In one assay, a h2520-109 polypeptide is immobilized in the wells of a microtiter plate. Radiolabeled h2520-109 binding partner (for example, iodinated h2520-109 binding partner) and the test molecule(s) can then be added either one at a time (in either order) or simultaneously to the wells. After incubation, the wells can be washed and counted using a scintillation counter, for radioactivity to determine the extent to which the binding partner bound to h2520-109 polypeptide. Typically, the molecules will be tested over a range of concentrations, and a series of control wells lacking one or more elements of the test assays can be used for accuracy in the evaluation of the results. An alternative to this method involves reversing the "positions" of the proteins, *i.e.*, immobilizing h2520-109 binding partner to the microtiter plate wells, incubating with the test molecule and radiolabeled h2520-109 polypeptide, and determining the extent of h2520-109 polypeptide binding. *See*, for example, chapter 18, *Current Protocols in Molecular Biology*, Ausubel *et al.*, eds., John Wiley & Sons, New York, NY (1995).

As an alternative to radiolabelling, a h2520-109 polypeptide or its binding partner may be conjugated to biotin and the presence of biotinylated protein can then be detected using streptavidin linked to an enzyme, such as horseradish peroxidase (HRP) or alkaline phosphatase (AP), that can be detected colorometrically, or by fluorescent tagging of streptavidin. An antibody directed to a h2520-109 polypeptide or to a h2520-109 binding partner and conjugated to biotin may also be used and can be detected after incubation with enzyme-linked streptavidin linked to AP or HRP.

A h2520-109 polypeptide or a h2520-109 like binding partner can also be immobilized by attachment to agarose beads, acrylic beads or other types of such inert solid phase substrates. The substrate-protein complex can be placed in a solution containing the complementary protein and the test compound. After incubation, the beads can be precipitated by centrifugation, and the amount of binding between a h2520-109 polypeptide and its binding partner can be assessed using the methods described herein. Alternatively, the substrate-protein complex can be immobilized in a column,

and the test molecule and complementary protein are passed through the column. The formation of a complex between a h2520-109 polypeptide and its binding partner can then be assessed using any of the techniques set forth herein, *i.e.*, radiolabelling, antibody binding or the like.

5 Another *in vitro* assay that is useful for identifying a test molecule which increases or decreases the formation of a complex between a h2520-109 polypeptide and a h2520-109 binding partner is a surface plasmon resonance detector system such as the BIAcore assay system (Pharmacia, Piscataway, NJ). The BIAcore system may be carried out using the manufacturer's protocol. This assay essentially involves the
10 covalent binding of either h2520-109 polypeptide or a h2520-109 binding partner to a dextran-coated sensor chip which is located in a detector. The test compound and the other complementary protein can then be injected, either simultaneously or sequentially, into the chamber containing the sensor chip. The amount of complementary protein that binds can be assessed based on the change in molecular mass which is physically
15 associated with the dextran-coated side of the sensor chip; the change in molecular mass can be measured by the detector system.

 In some cases, it may be desirable to evaluate two or more test compounds together for their ability to increase or decrease the formation of a complex between a h2520-109 polypeptide and a h2520-109 binding partner. In these cases, the assays set
20 forth herein can be readily modified by adding such additional test compound(s) either simultaneous with, or subsequent to, the first test compound. The remainder of the steps in the assay are set forth herein .

In vitro assays such as those described herein may be used advantageously to screen large numbers of compounds for effects on complex formation by h2520-109
25 polypeptide and h2520-109 binding partner. The assays may be automated to screen compounds generated in phage display, synthetic peptide, and chemical synthesis libraries.

 Compounds which increase or decrease the formation of a complex between a h2520-109 polypeptide and a h2520-109 binding partner may also be screened in cell
30 culture using cells and cell lines expressing either h2520-109 polypeptide or h2520-109 binding partner. Cells and cell lines may be obtained from any mammal, but preferably will be from human or other primate, canine, or rodent sources. The binding of a h2520-109 polypeptide to cells expressing h2520-109 binding partner at the surface is evaluated in the presence or absence of test molecules, and the extent of binding may be

determined by, for example, flow cytometry using a biotinylated antibody to a h2520-109 binding partner. Cell culture assays can be used advantageously to further evaluate compounds that score positive in protein binding assays described herein

Cell cultures can be used to screen the impact of a drug candidate. For example, drug candidates may decrease or increase the expression of the huE3 α polypeptide gene. In certain embodiments, the amount of huE3 α polypeptide or a fragment(s) that is produced may be measured after exposure of the cell culture to the drug candidate. In certain embodiments, one may detect the actual impact of the drug candidate on the cell culture. For example, the overexpression of a particular gene may have a particular impact on the cell culture. In such cases, one may test a drug candidate's ability to increase or decrease the expression of the gene or its ability to prevent or inhibit a particular impact on the cell culture. In other examples, the production of a particular metabolic product such as a fragment of a polypeptide, may result in, or be associated with, a disease or pathological condition. In such cases, one may test a drug candidate's ability to decrease the production of such a metabolic product in a cell culture.

A yeast two hybrid system (Chien *et al.*, *Proc. Natl. Acad. Sci. USA*, 88: 9578-9583, 1991) can be used to identify novel polypeptides that bind to a yeast-two hybrid bait construct can be generated in a vector (such as the pAS2-1 from Clontech) which encodes a yeast-two hybrid domain fused to the huE3 α polynucleotide. This bait construct may be used to screen human cDNA libraries wherein the cDNA library sequences are fused to GAL4 activation domains. Positive interactions will result in the activation of a reporter gene such as β -gal. Positive clones emerging from the screening may be characterized further to identify interacting proteins.

Internalizing Proteins

The TAT protein sequence (from HIV) can be used to internalize proteins into a cell by targeting the lipid bi-layer component of the cell membrane. See *e.g.*, Falwell *et al.*, *Proc. Natl. Acad. Sci.*, 91: 664-668, 1994. For example, an 11 amino acid sequence (YGRKKRRQRRR; SEQ ID NO: 16) of the HIV TAT protein (termed the "protein transduction domain", or TAT PDT) has been shown to mediate delivery of large bioactive proteins such as β -galactosidase and p27Kip across the cytoplasmic membrane and the nuclear membrane of a cell. See Schwarze *et al.*, *Science*, 285: 1569-1572, 1999; and Nagahara *et al.*, *Nature Medicine*, 4: 1449-1452, 1998. Schwarze *et al.* (*Science*, 285: 1569-72, 1999) demonstrated that cultured cells acquired β -gal

activity when exposed to a fusion of the TAT PDT and β -galactosidase. Injection of mice with the TAT- β -gal fusion proteins resulted in β -gal expression in a number of tissues, including liver, kidney, lung, heart, and brain tissue.

It will thus be appreciated that the TAT protein sequence may be used to internalize a desired protein or polypeptide into a cell. In the context of the present invention, the TAT protein sequence can be fused to another molecule such as a huE3 α antagonist (*i.e.*: anti-huE3 α selective binding agent or small molecule) and administered intracellularly to inhibit the activity of the huE3 α molecule. Where desired, the huE3 α protein itself, or a peptide fragment or modified form of huE3 α , may be fused to such a protein transducer for administering to cells using the procedures, described above.

Therapeutic Uses

The huE3 α nucleic acid molecules, polypeptides, and antagonists thereof (including, but not limited to, anti-huE3 α selective binding agents) can be used to treat, diagnose, and/or prevent a number of diseases, conditions, and disorders, including but not limited to cachexia, muscle wasting diseases and other catabolic disorders such as cancer cachexia, renal cachexia, inflammatory cachexia, muscle wasting disorders associated with metabolic acidosis, uremia, burns, hyperthyroidism, Cushing's syndrome and fasting, and denervation atrophy, diabetes mellitus, sepsis and AIDS wasting syndrome.

Those skilled in the art will recognize that many combinations of deletions, insertions, and substitutions (individually or collectively "variant(s)" herein) can be made within the amino acid sequences of the huE3 α polypeptide, provided that the resulting molecule is biologically active (*e.g.*, possesses the ability to affect one or more of the diseases and disorders such as those recited herein).

As contemplated by the present invention, a polypeptide, or antagonist thereof (including, but not limited to, anti-huE3 α selective binding agents) may be administered as an adjunct to other therapy and also with other pharmaceutical compositions suitable for the indication being treated. A polypeptide and any of one or more additional therapies or pharmaceutical formulations may be administered separately, sequentially, or simultaneously.

In a specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) thereof in combination (pretreatment, post-treatment, or concurrent

treatment) with secreted or soluble human fas antigen or recombinant versions thereof (WO96/20206 and Mountz *et al.*, *J. Immunology*, 155: 4829-4837; and EP 510 691. WO96/20206 discloses secreted human fas antigen (native and recombinant, including an Ig fusion protein), methods for isolating the genes responsible for coding the soluble recombinant human fas antigen, methods for cloning the gene in suitable vectors and cell types, and methods for expressing the gene to produce the inhibitors. EP 510 691 teaches DNAs coding for human fas antigen, including soluble fas antigen, vectors expressing for said DNAs and transformants transfected with the vector. When administered parenterally, doses of a secreted or soluble fas antigen fusion protein each are generally from about 1 microgram/kg to about 100 micrograms/kg.

Treatment of the diseases and disorders recited herein can include the use of first line drugs for control of pain and inflammation; these drugs are classified as non-steroidal, anti-inflammatory drugs (NSAIDs). Secondary treatments include corticosteroids, slow acting antirheumatic drugs (SAARDs), or disease modifying (DM) drugs. Information regarding the following compounds can be found in The Merck Manual of Diagnosis and Therapy, Sixteenth Edition, Merck, Sharp & Dohme Research Laboratories, Merck & Co., Rahway, NJ (1992) and in Pharmaprojects, PJB Publications Ltd.

In a specific embodiment, the present invention is directed to the use of a huE3 α , or antagonist (including, but not limited to, anti-huE3 α selective binding agents) and any of one or more NSAIDs for the treatment of the diseases and disorders recited herein. NSAIDs owe their anti-inflammatory action, at least in part, to the inhibition of prostaglandin synthesis (Goodman and Gilman in "The Pharmacological Basis of Therapeutics," MacMillan 7th Edition (1985)). NSAIDs can be characterized into at least nine groups: (1) salicylic acid derivatives; (2) propionic acid derivatives; (3) acetic acid derivatives; (4) fenamic acid derivatives; (5) carboxylic acid derivatives; (6) butyric acid derivatives; (7) oxicams; (8) pyrazoles and (9) pyrazolones.

In another specific embodiment, the present invention is directed to the use of an huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more salicylic acid derivatives, prodrug esters or pharmaceutically acceptable salts thereof. Such salicylic acid derivatives, prodrug esters and pharmaceutically acceptable salts thereof comprise: acetaminosalol, aloxiprin, aspirin, benorylate, bromosaligenin, calcium acetylsalicylate, choline magnesium

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In another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more fenamic acid derivatives, prodrug esters or pharmaceutically acceptable salts thereof. The fenamic acid derivatives, prodrug esters and pharmaceutically acceptable salts thereof comprise: enfenamic acid, etofenamate, flufenamic acid, isonixin, meclofenamic acid, meclofenamate sodium, medofenamic acid, mefenamic acid, niflumic acid, talniflumate, terofenamate, tolfenamic acid and ufenamate. Structurally related fenamic acid derivatives having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In an additional specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more carboxylic acid derivatives, prodrug esters or pharmaceutically acceptable salts thereof. The carboxylic acid derivatives, prodrug esters, and pharmaceutically acceptable salts thereof which can be used comprise: clidanac, diflunisal, flufenisal, inoridine, ketorolac and tinoridine. Structurally related carboxylic acid derivatives having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In yet another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more butyric acid derivatives, prodrug esters or pharmaceutically acceptable salts thereof. The butyric acid derivatives, prodrug esters, and pharmaceutically acceptable salts thereof comprise: bumadizon, butibufen, fenbufen and xenbucin. Structurally related butyric acid derivatives having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more oxicams, prodrug esters, or pharmaceutically acceptable salts thereof. The oxicams, prodrug esters, and pharmaceutically acceptable salts thereof comprise: droxicam, enolicam, isoxicam, piroxicam, sudoxicam, tenoxicam and 4-hydroxyl-1,2-benzothiazine 1,1-dioxide 4-(N-phenyl)-carboxamide. Structurally

related oxicams having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In still another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more pyrazoles, prodrug esters, or pharmaceutically acceptable salts thereof. The pyrazoles, prodrug esters, and pharmaceutically acceptable salts thereof which may be used comprise: difenamizole and epirizole. Structurally related pyrazoles having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In an additional specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment or, concurrent treatment) with any of one or more pyrazolones, prodrug esters, or pharmaceutically acceptable salts thereof. The pyrazolones, prodrug esters and pharmaceutically acceptable salts thereof which may be used comprise: apazone, azapropazone, benzpiperylon, feprazone, mofebutazone, morazone, oxyphenbutazone, phenylbutazone, pipebuzone, propylphenazone, ramifenazone, suxibuzone and thiazolinobutazone. Structurally related pyrazalones having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more of the following NSAIDs: e-acetamidocaproic acid, S-adenosyl-methionine, 3-amino-4-hydroxybutyric acid, amixetrine, anitrazafen, antrafenine, bendazac, bendazac lysinate, benzydamine, beprozin, broperamole, bucolome, bufezolac, ciproquazone, cloximate, dazidamine, deboxamet, detomidine, difenpiramide, difenpyramide, difisalamine, ditazol, emorfazone, fanetizole mesylate, fenflumizole, floctafenine, flumizole, flunixin, fluproquazone, fopirtoline, fosfosal, guaimesal, guaiazolene, isonixirn, lefetamine HCl, leflunomide, lofemizole, lotifazole, lysin clonixinate, meseclazone, nabumetone, nictindole, nimesulide, orgotein, orpanoxin, oxaceprol, oxapadol, paranyline, perisoxal, perisoxal citrate, pifoxime, piproxen, pirazolac, pirfenidone, proquazone, proxazole, thielavin B, tiflamizole, timegadine, tolectin, tolpadol, tryptamid and those designated by company code number such as

480156S, AA861, AD1590, AFP802, AFP860, AI77B, AP504, AU8001, BPPC, BW540C, CHINOIN 127, CN100, EB382, EL508, F1044, FK-506, GV3658, ITF182, KCNTEI6090, KME4, LA2851, MR714, MR897, MY309, ONO3144, PR823, PV102, PV108, R830, RS2131, SCR152, SH440, SIR133, SPAS510, SQ27239, ST281, SY6001, TA60, TAI-901 (4-benzoyl-1-indancarboxylic acid), TVX2706, U60257, UR2301 and WY41770. Structurally related NSAIDs having similar analgesic and anti-inflammatory properties to the NSAIDs are also intended to be encompassed by this group.

In still another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment or concurrent treatment) with any of one or more corticosteroids, prodrug esters or pharmaceutically acceptable salts thereof for the treatment of the diseases and disorders recited herein, including acute and chronic inflammation such as rheumatic diseases, graft versus host disease and multiple sclerosis. Corticosteroids, prodrug esters and pharmaceutically acceptable salts thereof include hydrocortisone and compounds which are derived from hydrocortisone, such as 21-acetoxypregnenolone, alclomerasone, algestone, amcinonide, beclomethasone, betamethasone, betamethasone valerate, budesonide, chloroprednisone, clobetasol, clobetasol propionate, clobetasone, clobetasone butyrate, clocortolone, clocprednol, corticosterone, cortisone, cortivazol, deflazacon, desonide, desoximetasone, dexamethasone, diflorasone, diflucortolone, difluprednate, enoxolone, fluazacort, fluclosonide, flumethasone, flumethasone pivalate, flucinolone acetonide, flunisolide, fluocinonide, fluorocinolone acetonide, fluocortin butyl, fluocortolone, fluocortolone hexanoate, diflucortolone valerate, fluorometholone, fluperolone acetate, fluprednidene acetate, fluprednisolone, flurandrenolide, formocortol, halcinonide, halometasone, halopredone acetate, hydro-cortamate, hydrocortisone, hydrocortisone acetate, hydrocortisone butyrate, hydrocortisone phosphate, hydrocortisone 21-sodium succinate, hydrocortisone tebutate, mazipredone, medrysone, meprednisone, methylprednisolone, mometasone furoate, paramethasone, prednicarbate, prednisolone, prednisolone 21-diedryaminoacetate, prednisolone sodium phosphate, prednisolone sodium succinate, prednisolone sodium 21-*m*-sulfobenzoate, prednisolone sodium 21-stearoglycolate, prednisolone tebutate, prednisolone 21-trimethylacetate, prednisone, prednival, prednylidene, prednylidene 21-diethylaminoacetate, tixocortol, triamcinolone, triamcinolone acetonide, triamcinolone benetonide and triamcinolone hexacetonide.

Structurally related corticosteroids having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In another specific embodiment, the present invention is directed to the use of an huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more slow-acting antirheumatic drugs (SAARDs) or disease modifying antirheumatic drugs (DMARDS), prodrug esters, or pharmaceutically acceptable salts thereof for the treatment of the diseases and disorders recited herein, including acute and chronic inflammation such as rheumatic diseases, graft versus host disease and multiple sclerosis. SAARDs or DMARDS, prodrug esters and pharmaceutically acceptable salts thereof comprise: allocupreide sodium, auranofin, aurothioglucose, aurothioglycanide, azathioprine, brequinar sodium, bucillamine, calcium 3-aurothio-2-propanol-1-sulfonate, chlorambucil, chloroquine, clobuzarit, cuproxoline, cyclo-phosphamide, cyclosporin, dapsone, 15-deoxyspergualin, diacerein, glucosamine, gold salts (*e.g.*, cycloquine gold salt, gold sodium thiomalate, gold sodium thiosulfate), hydroxychloroquine, hydroxychloroquine sulfate, hydroxyurea, kebusone, levamisole, lobenzarit, melittin, 6-mercaptopurine, methotrexate, mizoribine, mycophenolate mofetil, myoral, nitrogen mustard, D-penicillamine, pyridinol imidazoles such as SKNF86002 and SB203580, rapamycin, thiols, thymopoietin and vincristine. Structurally related SAARDs or DMARDS having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more COX2 inhibitors, prodrug esters or pharmaceutically acceptable salts thereof for the treatment of the diseases and disorders recited herein, including acute and chronic inflammation. Examples of COX2 inhibitors, prodrug esters or pharmaceutically acceptable salts thereof include, for example, celecoxib. Structurally related COX2 inhibitors having similar analgesic and anti-inflammatory properties are also intended to be encompassed by this group.

In still another specific embodiment, the present invention is directed to the use of a huE3 α polypeptide, or antagonist (including, but not limited to, anti-huE3 α selective binding agents) in combination (pretreatment, post-treatment, or concurrent treatment) with any of one or more antimicrobials, prodrug esters or pharmaceutically

acceptable salts thereof for the treatment of the diseases and disorders recited herein, including cachexia, muscle wasting diseases and other catabolic disorders. Antimicrobials include, for example, the broad classes of penicillins, cephalosporins and other beta-lactams, aminoglycosides, azoles, quinolones, macrolides, rifamycins, tetracyclines, sulfonamides, lincosamides and polymyxins. The penicillins include, but are not limited to penicillin G, penicillin V, methicillin, nafcillin, oxacillin, cloxacillin, dicloxacillin, floxacillin, ampicillin, ampicillin/sulbactam, amoxicillin, amoxicillin/clavulanate, hetacillin, cyclacillin, bacampicillin, carbenicillin, carbenicillin indanyl, ticarcillin, ticarcillin/clavulanate, azlocillin, mezlocillin, peperacillin, and mecillinam. The cephalosporins and other beta-lactams include, but are not limited to cephalothin, cephapirin, cephalixin, cephradine, cefazolin, cefadroxil, cefaclor, cefamandole, cefotetan, cefoxitin, ceruroxime, cefonicid, ceforadine, cefixime, cefotaxime, moxalactam, ceftizoxime, ceftriaxone, cephaloperazone, ceftazidime, imipenem and aztreonam. The aminoglycosides include, but are not limited to streptomycin, gentamicin, tobramycin, amikacin, netilmicin, kanamycin and neomycin. The azoles include, but are not limited to fluconazole. The quinolones include, but are not limited to nalidixic acid, norfloxacin, enoxacin, ciprofloxacin, ofloxacin, sparfloxacin and temafloxacin. The macrolides include, but are not limited to erythromycin, spiramycin and azithromycin. The rifamycins include, but are not limited to rifampin. The tetracyclines include, but are not limited to spicycline, chlortetracycline, clomocycline, demeclocycline, deoxycycline, guamecycline, lymecycline, meclocycline, methacycline, minocycline, oxytetracycline, penimepicycline, pipacycline, rolitetracycline, sancycline, senociclin and tetracycline. The sulfonamides include, but are not limited to sulfanilamide, sulfamethoxazole, sulfacetamide, sulfadiazine, sulfisoxazole and co-trimoxazole (trimethoprim/sulfamethoxazole). The lincosamides include, but are not limited to clindamycin and lincomycin. The polymyxins (polypeptides) include, but are not limited to polymyxin B and colistin.

Human E3 α Compositions and Administration

Therapeutic compositions are within the scope of the present invention. Such compositions may comprise a therapeutically effective amount of a huE3 α polypeptide, including a fragment, variant, derivative, or one or more selective binding agents which either inhibit or stimulate an activity of huE3 α in admixture with a

pharmaceutically acceptable agent such as a pharmaceutically acceptable formulation agent; wherein huE3 α refers to the polypeptide sequence of huE3 α I or huE3 α II.

Human E3 α pharmaceutical compositions typically include a therapeutically or prophylactically effective amount of huE3 α polypeptide, (an inhibitor of huE3 α action) nucleic acid molecule or selective binding agent in a mixture with one or more pharmaceutically and physiologically acceptable formulation agents selected for suitability with the mode of administration. Suitable formulation materials or pharmaceutically acceptable agents include, but are not limited to, antioxidants, preservatives, coloring, flavoring and diluting agents, emulsifying agents, suspending agents, solvents, fillers, bulking agents, buffers, delivery vehicles, diluents, excipients and/or pharmaceutical adjuvants. For example, a suitable vehicle or carrier may be water for injection, physiological saline solution, or artificial cerebrospinal fluid, possibly supplemented with other materials common in compositions for parenteral administration. Neutral buffered saline or saline mixed with serum albumin are further exemplary vehicles. The term "pharmaceutically acceptable carrier" or "physiologically acceptable carrier" as used herein refers to one or more formulation agents suitable for accomplishing or enhancing the delivery of the huE3 α polypeptide, nucleic acid molecule or selective binding agent as a pharmaceutical composition.

Acceptable formulation materials preferably are nontoxic to recipients and are preferably inert at the dosages and concentrations employed. The materials may include buffers such as phosphate, citrate, or other organic acids; antioxidants such as ascorbic acid; low molecular weight polypeptides; proteins, such as serum albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids such as glycine, glutamine, asparagine, arginine or lysine; monosaccharides, disaccharides, and other carbohydrates including glucose, mannose, or dextrans; chelating agents such as ethylenediamine tetraacetic acid (EDTA); sugar alcohols such as mannitol or sorbitol; salt-forming counterions such as sodium; and/or nonionic surfactants such as tween, pluronics, or polyethylene glycol (PEG).

Typically, a huE3 α molecule pharmaceutical composition will be administered in the form of a composition comprising a purified polypeptide, in conjunction with one or more physiologically acceptable agents. It will be appreciated that when used herein, the term "huE3 α molecule pharmaceutical composition" also encompasses compositions containing a nucleic acid molecule or selective binding agent of the present invention.

Neutral buffered saline or saline mixed with serum albumin are exemplary appropriate carriers. Other standard pharmaceutically acceptable agents such as diluents and excipients may be included as desired. For example, the huE3 α polypeptide product may be formulated as a lyophilizate using appropriate excipients such as sucrose. Other exemplary pharmaceutical compositions comprise Tris buffer of about pH 7.0-8.5, or acetate buffer of about pH 4.0-5.5, which may further include sorbitol or a suitable substitute therefor.

The primary vehicle or carrier in a pharmaceutical composition may be either aqueous or non-aqueous in nature. In addition, the composition may contain other formulation materials for modifying or maintaining the pH, osmolality, viscosity, clarity, color, sterility, stability, rate of dissolution, or odor of the formulation. Similarly, the composition may contain additional formulation materials for modifying or maintaining the rate of release of huE3 α polypeptide, nucleic acid molecule or selective binding agent, or for promoting the absorption or penetration of huE3 α such molecules.

The huE3 α molecule pharmaceutical compositions can be administered parenterally. Alternatively, the compositions may be administered through the digestive tract, such as orally, or by inhalation. When parenterally administered, the therapeutic compositions for use in this invention may be in the form of a pyrogen-free, parenterally acceptable aqueous solution. The preparation of such pharmaceutically acceptable compositions, with due regard to pH, isotonicity, stability and the like, is within the skill of the art.

A particularly suitable vehicle for parenteral injection is sterile distilled water in which a huE3 α polypeptide is formulated as a sterile, isotonic solution, properly preserved. Yet another preparation can involve the formulation of the desired molecule with an agent, such as injectable microspheres, bio-erodible particles or beads, or liposomes, that provides for the controlled or sustained release of the product which may then be delivered as a depot injection. Other suitable means for the introduction of the desired molecule include implantable drug delivery devices.

The pharmaceutical compositions of the present invention may include other components, for example parenterally acceptable preservatives, tonicity agents, cosolvents, wetting agents, complexing agents, buffering agents, antimicrobials, antioxidants and surfactants, as are well known in the art. For example, suitable tonicity enhancing agents include alkali metal halides (preferably sodium or potassium chloride),

mannitol, sorbitol, and the like. Suitable preservatives include, but are not limited to, benzalkonium chloride, thimerosal, phenethyl alcohol, methylparaben, propylparaben, chlorhexidine, sorbic acid, and the like. Hydrogen peroxide may also be used as preservative. Suitable cosolvents are for example glycerin, propylene glycol and polyethylene glycol. Suitable complexing agents are for example caffeine, polyvinylpyrrolidone, beta-cyclodextrin or hydroxypropyl-beta-cyclodextrin. Suitable surfactants or wetting agents include sorbitan esters, polysorbates such as polysorbate 80, tromethamine, lecithin, cholesterol, tyloxapal, and the like. The buffers can be conventional buffers such as borate, citrate, phosphate, bicarbonate, or Tris-HCl.

The formulation components are present in concentrations that are acceptable to the site of administration. For example, buffers are used to maintain the composition at physiological pH or at slightly lower pH, typically within a pH range of from about 5 to about 8.

In one embodiment of the present invention, huE3 α polypeptide compositions may be prepared for storage by mixing the selected composition having the desired degree of purity with optional physiologically acceptable carriers, excipients, or stabilizers (*Remington's pharmaceutical sciences*, 18th edition, A.R. Gennaro, ed., Mack Publishing Company (1990)) in the form of a lyophilized cake or an aqueous solution.

The optimal pharmaceutical formulation will be determined by one skilled in the art depending upon, for example, the intended route of administration, delivery format, and desired dosage. See for example, *Remington's Pharmaceutical Sciences*, pp. 1435-1712. Such compositions may influence the physical state, stability, rate of *in vivo* release, and rate of *in vivo* clearance of the present huE3 α polypeptides.

An effective amount of a huE3 α polypeptide composition to be employed therapeutically will depend, for example, upon the therapeutic objectives such as the indication for which the huE3 α polypeptide is being used, the route of administration, and the condition of the patient. Accordingly, the clinician may titer the dosage and modify the route of administration to obtain the optimal therapeutic effect. A typical dosage may range from about 0.1 $\mu\text{g/kg}$ to up to about 100 mg/kg or more, depending on the factors mentioned above. In other embodiments, the dosage may range from 1 $\mu\text{g/kg}$ up to about 100 mg/kg; or 5 $\mu\text{g/kg}$ up to about 100 mg/kg; or 0.1 $\mu\text{g/kg}$ up to about 100 mg/kg; or 1 $\mu\text{g/kg}$ up to about 100 mg/kg.

Typically, a clinician will administer the composition until a dosage is reached that achieves the desired effect. The composition may therefore be administered as a single dose, or as two or more doses (which may or may not contain the same amount of the desired molecule) over time, or as a continuous infusion via implantation device or catheter.

One skilled in the art will appreciate that the appropriate dosage levels for treatment will thus vary depending, in part, upon the molecule delivered, the therapeutic context, type of disorder under treatment, the age, and general health of the recipient.

The huE3 α molecule pharmaceutical composition to be used for *in vivo* administration typically must be sterile. This may be accomplished by filtration through sterile filtration membranes. Where the composition is lyophilized, sterilization using these methods may be conducted either prior to, or following, lyophilization and reconstitution. The composition for parenteral administration may be stored in lyophilized form or in solution. In addition, parenteral compositions generally are placed into a container having a sterile access port, for example, an intravenous solution bag or vial having a stopper pierceable by a hypodermic injection needle.

Once the pharmaceutical composition has been formulated, it may be stored in sterile vials as a solution, suspension, gel, emulsion, solid, or a dehydrated or lyophilized powder. Such formulations may be stored either in a ready-to-use form or in a form (*e.g.*, lyophilized) requiring reconstitution prior to administration.

In a specific embodiment, the present invention is directed to kits for producing a single-dose administration unit. The kits may each contain both a first container having a dried protein and a second container having an aqueous formulation. Also included within the scope of this invention are kits containing single and multi-chambered pre-filled syringes (*e.g.*, liquid syringes and lyosyringes).

An effective amount of a h2520-109 pharmaceutical composition to be employed therapeutically will depend, for example, upon the therapeutic context and objectives. One skilled in the art will appreciate that the appropriate dosage levels for treatment will thus vary depending, in part, upon the molecule delivered, the indication for which the h2520-109 molecule is being used, the route of administration, and the size (body weight, body surface or organ size) and condition (the age and general health) of the patient. Accordingly, the clinician may titer the dosage and modify the route of administration to obtain the optimal therapeutic effect. A typical dosage may range

from about 0.1 mg/kg to up to about 100 mg/kg or more, depending on the factors mentioned above. In other embodiments, the dosage may range from 0.1 mg/kg up to about 100 mg/kg; or 1 mg/kg up to about 100 mg/kg; or 5 mg/kg up to about 100 mg/kg.

The frequency of dosing will depend upon the pharmacokinetic parameters of the h2520-109 molecule in the formulation used. Typically, a clinician will administer the composition until a dosage is reached that achieves the desired effect. The composition may therefore be administered as a single dose, or as two or more doses (which may or may not contain the same amount of the desired molecule) over time, or as a continuous infusion via implantation device or catheter.

Pharmaceutical compositions such as (1) slow-release formulations, (2) inhalant mists, or (3) orally active formulations are also envisioned. The huE3 α molecule pharmaceutical composition generally is formulated for parenteral administration. Such parenterally administered therapeutic compositions are typically in the form of a pyrogen-free, parenterally acceptable aqueous solution comprising the desired huE3 α molecule in a pharmaceutically acceptable vehicle. The huE3 α molecule pharmaceutical compositions also may include particulate preparations of polymeric compounds such as polylactic acid, polyglycolic acid, etc. or the introduction of the molecule into liposomes. Hyaluronic acid may also be used, and this may have the effect of promoting sustained duration in the circulation.

In one embodiment, a pharmaceutical composition may be formulated for inhalation. For example, huE3 α polypeptide may be formulated as a dry powder for inhalation. Human E3 α polypeptide or nucleic acid molecule inhalation solutions may also be formulated in a liquefied propellant for aerosol delivery, with or without a liquefied propellant. In yet another embodiment, solutions may be nebulized. Pulmonary administration is further described in PCT WO94/20069, which describes pulmonary delivery of chemically modified proteins.

It is also contemplated that certain formulations may be administered orally. In one embodiment of the present invention, huE3 α polypeptides which are administered in this fashion can be formulated with or without those carriers customarily used in the compounding of solid dosage forms such as tablets and capsules. For example, a capsule may be designed to release the active portion of the formulation at the point in the gastrointestinal tract when bioavailability is maximized and pre-systemic degradation is minimized. Additional agents can be included to facilitate absorption of the huE3 α polypeptide. Diluents, flavorings, low melting point waxes, vegetable oils,

lubricants, suspending agents, tablet disintegrating agents, and binders may also be employed.

Another pharmaceutical composition may involve an effective quantity of huE3 α polypeptides in a mixture with non-toxic excipients which are suitable for the manufacture of tablets. By dissolving the tablets in sterile water, or other appropriate vehicle, solutions can be prepared in unit dose form. Suitable excipients include, but are not limited to, inert diluents, such as calcium carbonate, sodium carbonate or bicarbonate, lactose, or calcium phosphate; or binding agents, such as starch, gelatin, or acacia; or lubricating agents such as magnesium stearate, stearic acid, or talc.

Additional huE3 α molecule formulations will be evident to those skilled in the art, including formulations involving huE3 α molecules in combination with one or more other therapeutic agents. Techniques for formulating a variety of other sustained- or controlled-delivery means, such as liposome carriers, bio-erodible microparticles or porous beads and depot injections, are also known to those skilled in the art. See for example, PCT/US93/00829 which describes controlled release of porous polymeric microparticles for the delivery of pharmaceutical compositions.

Additional examples of sustained-release preparations include semipermeable polymer matrices in the form of shaped articles, e.g. films, or microcapsules. Sustained release matrices may include polyesters, hydrogels, polylactides (U.S. 3,773,919, EP 58,481), copolymers of L-glutamic acid and gamma ethyl-L-glutamate (Sidman *et al.*, *Biopolymers*, 22: 547-556, 1983), poly (2-hydroxyethyl-methacrylate) (Langer *et al.*, *J. Biomed. Mater. Res.*, 15: 167-27, 1981; and Langer, *Chem. Tech.*, 12: 98-105, 1982), ethylene vinyl acetate (Langer *et al.*, *supra*) or poly-D(-)-3-hydroxybutyric acid (EP 133,988). Sustained-release compositions also may include liposomes, which can be prepared by any of several methods known in the art. (See e.g., Eppstein *et al.*, *Proc. Natl. Acad. Sci. USA*, 82: 3688-3692, 1985; EP 36,676; EP 88,046; EP 143,949.)

Regardless of the manner of administration, the specific dose may be calculated according to body weight, body surface area or organ size. Further refinement of the appropriate dosage is routinely made by those of ordinary skill in the art and is within the ambit of tasks routinely performed by them. Appropriate dosages may be ascertained through use of appropriate dose-response data.

The route of administration of the pharmaceutical composition is in accord with known methods, e.g. oral, inhalation, injection or infusion by intravenous,

intraperitoneal, intracerebral (intra-parenchymal), intracerebroventricular, intramuscular, intra-ocular, intraarterial, intraportal, or intralesional routes, or by sustained release systems or implantation device. Where desired, the compositions may be administered continuously by infusion, by bolus injection devices or by implantation device.

5 Alternatively or additionally, the composition may be administered locally via implantation into the affected area of a membrane, sponge, or other appropriate material on to which the desired molecule has been absorbed or encapsulated. Where an implantation device is used, the device may be implanted into any suitable tissue or organ, and delivery of the desired molecule may be directly
10 through the device via diffusion, time-released bolus, or via continuous administration, or via catheter using continuous infusion.

 It will further be appreciated that the huE3 α polypeptides, including fragments, variants, and derivatives, may be employed alone, together, or in combination with other polypeptides and pharmaceutical compositions. For example, the huE3 α
15 polypeptides may be used in combination with cytokines, growth factors, antibiotics, anti-inflammatories, and/or chemotherapeutic agents as is appropriate for the indication being treated.

 In some cases, it may be desirable to use huE3 α pharmaceutical compositions in an *ex vivo* manner. In such instances, cells, tissues, or organs that have
20 been removed from the patient are exposed to huE3 α pharmaceutical compositions after which the cells, tissues and/or organs are subsequently implanted back into the patient.

 In other cases, a huE3 α polypeptide can be delivered by implanting certain cells that have been genetically engineered, using methods such as those described herein, to express and secrete the polypeptides. Such cells may be animal or
25 human cells, and may be autologous, heterologous, or xenogeneic. Optionally, the cells may be immortalized. However, in order to decrease the chance of an immunological response, the cells may be encapsulated to avoid infiltration of surrounding tissues. The encapsulation materials are typically biocompatible, semi-permeable polymeric enclosures or membranes that allow the release of the protein product(s) but prevent the
30 destruction of the cells by the patient's immune system or by other detrimental factors from the surrounding tissues.

 Additional embodiments of the present invention relate to cells and methods (e.g., homologous recombination and /or other recombinant production methods) for both the *in vitro* production of therapeutic polypeptides by means of

homologous recombination and for the production and delivery of therapeutic polypeptides by gene therapy or cell therapy.

It is further envisioned that huE3 α polypeptides can be produced by homologous recombination, or with recombinant production methods utilizing control elements introduced into cells already containing DNA encoding huE3 α polypeptides. For example, homologous recombination methods may be used to modify a cell that contains a normally transcriptionally silent huE3 α gene, or an under expressed gene, and thereby produce a cell which expresses therapeutically efficacious amounts of huE3 α polypeptides. Homologous recombination is a technique originally developed for targeting genes to induce or correct mutations in transcriptionally active genes. Kucherlapati, *Prog. in Nucl. Acid Res. & Mol. Biol.*, 36:301, 1989. The basic technique was developed as a method for introducing specific mutations into specific regions of the mammalian genome (Thomas *et al.*, *Cell*, 44: 419-428, 1986; Thomas and Capecchi, *Cell*, 51:503-512, 1987; Doetschman *et al.*, *Proc. Natl. Acad. Sci.*, 85: 8583-8587, 1988) or to correct specific mutations within defective genes (Doetschman *et al.*, *Nature*, 330: 576-578, 1987). Exemplary homologous recombination techniques are described in U.S. Patent No. 5,272,071 (EP 9193051, EP Publication No. 505500; PCT/US90/07642, International Publication No. WO 91/09955).

Through homologous recombination, the DNA sequence to be inserted into the genome can be directed to a specific region of the gene of interest by attaching it to targeting DNA. The targeting DNA is a nucleotide sequence that is complementary (homologous) to a region of the genomic DNA. Small pieces of targeting DNA that are complementary to a specific region of the genome are put in contact with the parental strand during the DNA replication process. It is a general property of DNA that has been inserted into a cell to hybridize, and therefore, recombine with other pieces of endogenous DNA through shared homologous regions. If this complementary strand is attached to an oligonucleotide that contains a mutation or a different sequence or an additional nucleotide, it too is incorporated into the newly synthesized strand as a result of the recombination. As a result of the proofreading function, it is possible for the new sequence of DNA to serve as the template. Thus, the transferred DNA is incorporated into the genome.

Attached to these pieces of targeting DNA are regions of DNA which may interact with or control the expression of a huE3 α polypeptide, *e.g.*, flanking sequences. For example, a promoter/enhancer element, a suppressor, or an exogenous

transcription modulatory element is inserted in the genome of the intended host cell in proximity and orientation sufficient to influence the transcription of DNA encoding the desired huE3 α polypeptide. The control element controls a portion of the DNA present in the host cell genome. Thus, the expression of huE3 α polypeptide may be achieved not by transfection of DNA that encodes the huE3 α gene itself, but rather by the use of targeting DNA (containing regions of homology with the endogenous gene of interest) coupled with DNA regulatory segments that provide the endogenous gene sequence with recognizable signals for transcription of a huE3 α polypeptide.

In an exemplary method, the expression of a desired targeted gene in a cell (*i.e.*, a desired endogenous cellular gene) is altered by the introduction, by homologous recombination into the cellular genome at a preselected site, by the introduction of DNA which includes at least a regulatory sequence, an exon and a splice donor site. These components are introduced into the chromosomal (genomic) DNA in such a manner that this, in effect, results in the production of a new transcription unit (in which the regulatory sequence, the exon and the splice donor site present in the DNA construct are operatively linked to the endogenous gene). As a result of the introduction of these components into the chromosomal DNA, the expression of the desired endogenous gene is altered.

Altered gene expression, as described herein, encompasses activating (or causing to be expressed) a gene which is normally silent (unexpressed) in the cell as obtained, as well as increasing the expression of a gene which is not expressed at physiologically significant levels in the cell as obtained. The embodiments further encompass changing the pattern of regulation or induction such that it is different from the pattern of regulation or induction that occurs in the cell as obtained, and reducing (including eliminating) the expression of a gene which is expressed in the cell as obtained.

One method by which homologous recombination can be used to increase, or cause, huE3 α polypeptide production from a cell's endogenous huE3 α gene involves first using homologous recombination to place a recombination sequence from a site-specific recombination system (*e.g.*, Cre/loxP, FLP/FRT) (Sauer, *Current Opinion In Biotechnology*, 5: 521-527, 1994; Sauer, *Methods In Enzymology*, 225: 890-900, 1993) upstream (that is, 5' to) of the cell's endogenous genomic huE3 α coding region. A plasmid containing a recombination site homologous to the site that was placed just upstream of the genomic huE3 α coding region is introduced into the modified cell line

along with the appropriate recombinase enzyme. This recombinase causes the plasmid to integrate, via the plasmid's recombination site, into the recombination site located just upstream of the genomic huE3 α coding region in the cell line (Baubonis and Sauer, *Nucleic Acids Res.*, 21: 2025-2029, 1993; O'Gorman *et al.*, *Science*, 251: 1351-1355, 1991). Any flanking sequences known to increase transcription (e.g., enhancer/promoter, intron, translational enhancer), if properly positioned in this plasmid, would integrate in such a manner as to create a new or modified transcriptional unit resulting in *de novo* or increased huE3 α polypeptide production from the cell's endogenous huE3 α gene.

A further method to use the cell line in which the site specific recombination sequence had been placed just upstream of the cell's endogenous genomic huE3 α coding region is to use homologous recombination to introduce a second recombination site elsewhere in the cell line's genome. The appropriate recombinase enzyme is then introduced into the two-recombination-site cell line, causing a recombination event (deletion, inversion, translocation) (Sauer, *Current Opinion In Biotechnology*, 5: 521-527, 1994; Sauer, *Methods In Enzymology*, 225: 890-900, 1993) that would create a new or modified transcriptional unit resulting in *de novo* or increased huE3 α polypeptide production from the cell's endogenous huE3 α gene.

An additional approach for increasing, or causing, the expression of huE3 α polypeptide from a cell's endogenous huE3 α gene involves increasing, or causing, the expression of a gene or genes (e.g., transcription factors) and/or decreasing the expression of a gene or genes (e.g., transcriptional repressors) in a manner which results in *de novo* or increased huE3 α polypeptide production from the cell's endogenous huE3 α gene. This method includes the introduction of a non-naturally occurring polypeptide (e.g., a polypeptide comprising a site specific DNA binding domain fused to a transcriptional factor domain) into the cell such that *de novo* or increased huE3 α polypeptide production from the cell's endogenous huE3 α gene results.

The present invention further relates to DNA constructs useful in the method of altering expression of a target gene. In certain embodiments, the exemplary DNA constructs comprise: (a) one or more targeting sequences; (b) a regulatory sequence; (c) an exon; and (d) an unpaired splice-donor site. The targeting sequence in the DNA construct directs the integration of elements (a)-(d) into a target gene in a cell such that the elements (b)-(d) are operatively linked to sequences of the endogenous target gene. In another embodiment, the DNA constructs comprise: (a) one or more

targeting sequences, (b) a regulatory sequence, (c) an exon, (d) a splice-donor site, (e) an intron, and (f) a splice-acceptor site, wherein the targeting sequence directs the integration of elements (a)-(f) such that the elements of (b)-(f) are operatively linked to the endogenous gene. The targeting sequence is homologous to the preselected site in the cellular chromosomal DNA with which homologous recombination is to occur. In the construct, the exon is generally 3' of the regulatory sequence and the splice-donor site is 3' of the exon.

If the sequence of a particular gene is known, such as the nucleic acid sequence encoding a huE3 α polypeptide presented herein, a piece of DNA that is complementary to a selected region of the gene can be synthesized or otherwise obtained, such as by appropriate restriction of the native DNA at specific recognition sites bounding the region of interest. This piece serves as a targeting sequence upon insertion into the cell and will hybridize to its homologous region within the genome. If this hybridization occurs during DNA replication, this piece of DNA, and any additional sequence attached thereto, will act as an Okazaki fragment and will be incorporated into the newly synthesized daughter strand of DNA. The present invention, therefore, includes nucleotides encoding a huE3 α polypeptide, which nucleotides may be used as targeting sequences.

Human E3 α polypeptide cell therapy, *e.g.*, the implantation of cells producing huE3 α polypeptides, is also contemplated. This embodiment involves implanting cells capable of synthesizing and secreting a biologically active form of huE3 α polypeptide. Such huE3 α polypeptide-producing cells can be cells that are natural producers of huE3 α polypeptides or may be recombinant cells whose ability to produce huE3 α polypeptides has been augmented by transformation with a gene encoding the desired huE3 α polypeptide or with a gene augmenting the expression of huE3 α polypeptide. Such a modification may be accomplished by means of a vector suitable for delivering the gene as well as promoting its expression and secretion. In order to minimize a potential immunological reaction in patients being administered a huE3 α polypeptide, as may occur with the administration of a polypeptide of a foreign species, it is preferred that the natural cells producing huE3 α polypeptide be of human origin and produce huE3 α polypeptide. Likewise, it is preferred that the recombinant cells producing huE3 α polypeptide be transformed with an expression vector containing a gene encoding a human huE3 α polypeptide.

Implanted cells may be encapsulated to avoid the infiltration of surrounding tissue. Human or non-human animal cells may be implanted in patients in biocompatible, semipermeable polymeric enclosures or membranes that allow the release of huE3 α polypeptide, but that prevent the destruction of the cells by the patient's immune system or by other detrimental factors from the surrounding tissue. Alternatively, the patient's own cells, transformed to produce huE3 α polypeptides *ex vivo*, may be implanted directly into the patient without such encapsulation.

Techniques for the encapsulation of living cells are known in the art, and the preparation of the encapsulated cells and their implantation in patients may be routinely accomplished. For example, Baetge *et al.* (WO95/05452; PCT/US94/09299) describe membrane capsules containing genetically engineered cells for the effective delivery of biologically active molecules. The capsules are biocompatible and are easily retrievable. The capsules encapsulate cells transfected with recombinant DNA molecules comprising DNA sequences coding for biologically active molecules operatively linked to promoters that are not subject to down regulation *in vivo* upon implantation into a mammalian host. The devices provide for the delivery of the molecules from living cells to specific sites within a recipient. In addition, *see* U.S. Patent Nos. 4,892,538, 5,011,472, and 5,106,627. A system for encapsulating living cells is described in PCT Application WO91/10425 of Aebischer *et al.* *See also*, PCT Application WO91/10470 of Aebischer *et al.*, Winn *et al.*, *Exper. Neurol.*, 113: 322-329, 1991, Aebischer *et al.*, *Exper. Neurol.*, 111: 269-275, 1991; and Tresco *et al.*, *ASAIO*, 38: 17-23, 1992.

In vivo and *in vitro* gene therapy delivery of huE3 α polypeptides is also envisioned. *In vivo* gene therapy may be accomplished by introducing the gene encoding huE3 α polypeptide into cells via local injection of a huE3 α nucleic acid molecule or by other appropriate viral or non-viral delivery vectors (Hefti, *Neurobiology*, 25: 1418-1435, 1994). For example, a nucleic acid molecule encoding a huE3 α polypeptide may be contained in an adeno-associated virus vector for delivery to the targeted cells (*e.g.*, Johnson, International Publication No. WO95/34670; International Application No. PCT/US95/07178). The recombinant adeno-associated virus (AAV) genome typically contains AAV inverted terminal repeats flanking a DNA sequence encoding a huE3 α polypeptide operably linked to functional promoter and polyadenylation sequences.

Alternative suitable viral vectors include, but are not limited to, retrovirus, adenovirus, herpes simplex virus, lentivirus, hepatitis virus, parvovirus, papovavirus, poxvirus, alphavirus, coronavirus, rhabdovirus, paramyxovirus, and papilloma virus vectors. U.S. Patent No. 5,672,344 describes an *in vivo* viral-mediated gene transfer system involving a recombinant neurotrophic HSV-1 vector. U.S. Patent No. 5,399,346 provides examples of a process for providing a patient with a therapeutic protein by the delivery of human cells which have been treated *in vitro* to insert a DNA segment encoding a therapeutic protein. Additional methods and materials for the practice of gene therapy techniques are described in U.S. Patent No. 5,631,236 involving adenoviral vectors; U.S. Patent No. 5,672,510 involving retroviral vectors; and U.S. 5,635,399 involving retroviral vectors expressing cytokines.

Nonviral delivery methods include, but are not limited to, liposome-mediated transfer, naked DNA delivery (direct injection), receptor-mediated transfer (ligand-DNA complex), electroporation, calcium phosphate precipitation, and microparticle bombardment (*e.g.*, gene gun). Gene therapy materials and methods may also include the use of inducible promoters, tissue-specific enhancer-promoters, DNA sequences designed for site-specific integration, DNA sequences capable of providing a selective advantage over the parent cell, labels to identify transformed cells, negative selection systems and expression control systems (safety measures), cell-specific binding agents (for cell targeting), cell-specific internalization factors, and transcription factors to enhance expression by a vector as well as methods of vector manufacture. Such additional methods and materials for the practice of gene therapy techniques are described in U.S. Patent No. 4,970,154 involving electroporation techniques; WO96/40958 involving nuclear ligands; U.S. Patent No. 5,679,559 describing a lipoprotein-containing system for gene delivery; U.S. Patent No. 5,676,954 involving liposome carriers; U.S. Patent No. 5,593,875 concerning methods for calcium phosphate transfection; and U.S. Patent No. 4,945,050 wherein biologically active particles are propelled at cells at a speed whereby the particles penetrate the surface of the cells and become incorporated into the interior of the cells.

In yet other embodiments, regulatory elements can be included for the controlled expression of the huE3 α gene in the target cell. Such elements are turned on in response to an appropriate effector. In this way, a therapeutic polypeptide can be expressed when desired. One conventional control means involves the use of small molecule dimerizers or rapalogs (as described in WO9641865 (PCT/US96/099486);

WO9731898 (PCT/US97/03137) and WO9731899 (PCT/US95/03157)) used to dimerize chimeric proteins which contain a small molecule-binding domain and a domain capable of initiating biological process, such as a DNA-binding protein or transcriptional activation protein. The dimerization of the proteins can be used to initiate transcription of the huE3 α gene.

Other suitable control means or gene switches include, but are not limited to, the following systems. Mifepristone (RU486) is used as a progesterone antagonist. The binding of a modified progesterone receptor ligand-binding domain to the progesterone antagonist activates transcription by forming a dimer of two transcription factors which then pass into the nucleus to bind DNA. The ligand binding domain is modified to eliminate the ability of the receptor to bind to the natural ligand. The modified steroid hormone receptor system is further described in U.S. 5,364,791; WO9640911, and WO9710337.

Yet another control system uses ecdysone (a fruit fly steroid hormone) which binds to and activates an ecdysone receptor (cytoplasmic receptor). The receptor then translocates to the nucleus to bind a specific DNA response element (promoter from ecdysone-responsive gene). The ecdysone receptor includes a transactivation domain/DNA-binding domain/ligand-binding domain to initiate transcription. The ecdysone system is further described in U.S. 5,514,578; WO9738117; WO9637609; and WO9303162.

Another control means uses a positive tetracycline-controllable transactivator. This system involves a mutated tet repressor protein DNA-binding domain (mutated tet R-4 amino acid changes which resulted in a reverse tetracycline-regulated transactivator protein, *i.e.*, it binds to a tet operator in the presence of tetracycline) linked to a polypeptide which activates transcription. Such systems are described in U.S. Patent Nos. 5,464,758; 5,650,298 and 5,654,168.

Additional expression control systems and nucleic acid constructs are described in U.S. Patent Nos. 5,741,679 and 5,834,186 to Innovir Laboratories Inc.

One example of a gene therapy technique is to use the huE3 α gene (either genomic DNA, cDNA, and/or synthetic DNA encoding a huE3 α polypeptide which may be operably linked to a constitutive or inducible promoter to form a "gene therapy DNA construct". The promoter may be homologous or heterologous to the endogenous huE3 α gene, provided that it is active in the cell or tissue type into which the construct will be inserted. Other components of the gene therapy DNA construct may optionally include,

DNA molecules designed for site-specific integration (*e.g.*, endogenous sequences useful for homologous recombination), tissue-specific promoter, enhancer(s) or silencer(s), DNA molecules capable of providing a selective advantage over the parent cell, DNA molecules useful as labels to identify transformed cells, negative selection systems, cell specific binding agents (as, for example, for cell targeting), cell-specific internalization factors, and transcription factors to enhance expression by a vector as well as factors to enable vector manufacture.

This gene therapy DNA construct can then be introduced into cells (either *ex vivo* or *in vivo*). One means for introducing the gene therapy DNA construct is by means of viral vectors as described herein. Certain vectors, such as retroviral vectors, will deliver the gene therapy DNA construct to the chromosomal DNA of the cells, and the gene therapy DNA construct can integrate into the chromosomal DNA. Other vectors will function as episomes, and the gene therapy DNA construct will remain in the cytoplasm.

Another means to increase endogenous huE3 α polypeptide expression in a cell via gene therapy is to insert one or more enhancer elements into the huE3 α polypeptide promoter, where the enhancer element(s) can serve to increase transcriptional activity of the huE3 α gene. The enhancer element(s) used will be selected based on the tissue in which one desires to activate the gene(s); enhancer elements known to confer promoter activation in that tissue will be selected. For example, if a gene encoding a huE3 α polypeptide is to be "turned on" in T-cells, the *lck* promoter enhancer element may be used. Here, the functional portion of the transcriptional element to be added may be inserted into a fragment of DNA containing the huE3 α polypeptide promoter (and optionally, inserted into a vector and/or 5' and/or 3' flanking sequence(s), etc.) using standard cloning techniques. This construct, known as a "homologous recombination construct", can then be introduced into the desired cells either *ex vivo* or *in vivo*.

Gene therapy can be used to decrease huE3 α polypeptide expression by modifying the nucleotide sequence of the endogenous promoter(s). Such modification is typically accomplished via homologous recombination methods. For example, a DNA molecule containing all or a portion of the promoter of the huE3 α gene(s) selected for inactivation can be engineered to remove and/or replace pieces of the promoter that regulate transcription. For example the TATA box and/or the binding site of a transcriptional activator of the promoter may be deleted using standard molecular

biology techniques; such deletion can inhibit promoter activity thereby repressing the transcription of the corresponding huE3 α gene. The deletion of the TATA box or the transcription activator binding site in the promoter may be accomplished by generating a DNA construct comprising all or the relevant portion of the huE3 α polypeptide promoter(s) (from the same or a related species as the huE3 α gene(s) to be regulated) in which one or more of the TATA box and/or transcriptional activator binding site nucleotides are mutated via substitution, deletion and/or insertion of one or more nucleotides. As a result, the TATA box and/or activator binding site has decreased activity or is rendered completely inactive. This construct, which also will typically contain at least about 500 bases of DNA that correspond to the native (endogenous) 5' and 3' DNA sequences adjacent to the promoter segment that has been modified, may be introduced into the appropriate cells (either *ex vivo* or *in vivo*) either directly or via a viral vector as described herein. Typically, the integration of the construct into the genomic DNA of the cells will be via homologous recombination, where the 5' and 3' DNA sequences in the promoter construct can serve to help integrate the modified promoter region via hybridization to the endogenous chromosomal DNA.

Other gene therapy methods may also be employed where it is desirable to inhibit the activity of one or more huE3 α polypeptides. For example, antisense DNA or RNA molecules, which have a sequence that is complementary to at least a portion of the selected huE3 α gene(s) can be introduced into the cell. Typically, each such antisense molecule will be complementary to the start site (5' end) of each selected huE3 α gene. When the antisense molecule then hybridizes to the corresponding huE3 α mRNA, translation of this mRNA is prevented or reduced. It will also be appreciated by those skilled in the art that antisense and ribozyme molecules may also be administered directly.

Alternatively, gene therapy may be employed to create a dominant-negative inhibitor of one or more huE3 α polypeptides. In this situation, the DNA encoding a mutant full length or truncated polypeptide of each selected huE3 α polypeptide can be prepared and introduced into the cells of a patient using either viral or non-viral methods as described herein. Each such mutant is typically designed to compete with endogenous polypeptide in its biological role.

Additional Uses of huE3 α Nucleic Acids and Polypeptides

Nucleic acid molecules of the present invention may be used to map the locations of the huE3 α gene and related genes on chromosomes. Mapping may be done by techniques known in the art, such as PCR amplification and *in situ* hybridization.

5 The nucleic acid molecules are also used as antisense inhibitors of huE3 α polypeptide expression. Such inhibition may be effected by nucleic acid molecules which are complementary to and hybridize to expression control sequences (triple helix formation) or to huE3 α mRNA. Antisense probes may be designed by available techniques using the sequence of huE3 α nucleic acid molecules disclosed herein.
10 Antisense inhibitors provide information relating to the decrease or absence of a huE3 α polypeptide in a cell or organism.

Hybridization probes may be prepared using the huE3 α nucleic acid sequences provided herein to screen cDNA, genomic or synthetic DNA libraries for related sequences. Regions of the DNA and/or amino acid sequence of huE3 α
15 polypeptide that exhibit significant identity to known sequences are readily determined using sequence alignment algorithms as described herein and those regions may be used to design probes for screening.

Human E3 α nucleic acid molecules, as well as fragments, variants, and/or derivatives that do not themselves encode biologically active polypeptides, may be
20 useful as hybridization probes in diagnostic assays to test, either qualitatively or quantitatively, for the presence of huE3 α DNA or corresponding RNA in mammalian tissue or bodily fluid samples.

Human E3 α polypeptide fragments, variants, and/or derivatives, whether biologically active or not, are also useful for preparing antibodies that bind to a huE3 α
25 polypeptide. The antibodies may be used for *in vitro* diagnostic purposes, including, but not limited to, use in labeled form to detect the presence of huE3 α polypeptide in a body fluid or cell sample.

The full length cDNAs encoding huE3 α I was subcloned into pCR 2.1 vector (Invitrogen, Cat.# K2030-40). The full length cDNA encoding huE3 α II was
30 subcloned into pcDNA 3.1/His A vector (Invitrogen Cat.#V38-20). The full length cDNA encoding muE3 α II was subcloned into pCR 2.1 vector (Invitrogen). The above plasmids were deposited on March 15, 2000 to the American Type Culture Collection, 10801 University Boulevard, Manassas, VA 20110-2209 . The plasmid containing

huE3 α 1 is designated PTA-1489, the plasmid containing huE3 α II is designated PTA-1490 and the plasmid containing muE3 α II is designated PTA-1488.

The following examples are intended for illustration purposes only, and should not be construed as limiting the scope of the invention in any way.

EXAMPLE 1

Cloning of cDNA Encoding Human E3 α I

Materials and methods for cDNA cloning and analysis are described in Sambrook *et al., supra.* which is incorporated herein by reference.

BLAST analysis of the Genebank dbEST database with the full length murine E3 α ubiquitin ligase nucleotide sequence (muE3I; Genebank Accession No.: AF061555; SEQ ID NO: 15), revealed 4 human EST sequences (Genebank accession numbers A1187306, A192195, A187306, and A1400279) which potentially encode different regions of a novel human E3 α ubiquitin ligase ortholog (huE3 α I) gene.

Based on these EST sequences, two sets of PCR primers (#2282-91/2282-93 and #2282-94/2282-97) were designed. These sequences are set out below in Table III.

Table III

Primer	Sequence	SEQ ID NO:
2282-91	CTC CTC GAG TCT GCG TCA AAC	7
2385-35	TCT GCA TAT GTT CAG CCT TGC TA	8
2282-94	GTA TGA ACT TGC CGA GGC TTT TA	9
2294-37	CAA TAC TTT CCC AGC CCT CAG AA	10

The primer sets #2282-91/2282-93 (SEQ ID NOS: 7 and 8) and #2282-94/2294-37 (SEQ ID NOS: 9 and 10) were used to generate two PCR products which span the whole huE3 α I gene including the 5' and 3' untranslated regions. Polymerase chain reactions (PCR) were performed using a Perkin-Elmer 9600 thermocycler. In general, 50 μ l PCR reactions contained 24 μ l of H₂O, 5 μ l of 10x cDNA PCR Reaction Buffer (Clontech), 2 μ l of 10 mM dNTP mix (dATP, dCTP, dGTP, dTTP), 1 μ l of Primer 2282-91 or 2282-94 (20 μ l), 1 μ l of Primer 2285-35 or 2294-37 (20 μ l), 2 μ l of 50x Advantage 2 Polymerase Mix (Clontech) and 15 μ l of Marathon Ready cDNA from a human heart library (Clontech cat.# 7404-1) or a human muscle library (Clontech cat.# 7413-1). The reaction mixture was incubated at 94°C for 30 seconds, followed by 40 cycles of 94°C for 30 seconds, 60°C for 30 seconds, and 72°C for 5 minutes.

The PCR products were electrophoresed on a 1% agarose gel as described by Sambrook *et al.*, *supra*. The appropriate sized bands (14 kB and 3 kB) were excised from the agarose gel and purified with the QIAquick Gel Extraction kit (Qiagen, cat# 28704). The two purified DNA fragments were subcloned into pCR2.1 vectors and transformed into *E. coli* (Strain INV α F) utilizing the Invitrogen Original TA Cloning kit (cat.# K2000-40).

After subcloning, DNA plasmids were purified with the QIAprep Spin Miniprep kit (cat# 27104). The sequence of the PCR products were verified by automated sequencing with the Prism 377 Sequencer and the Big Dye Terminator Ready Reaction mix with AmpliTaq DNA polymerase (Perkin Elmer Applied Biosystems). Each sequencing reaction was performed in a Perkin Elmer 9600 thermocycler with 25 cycles of 96°C for 10 seconds, 50°C for 5 seconds and 60°C for 2 minutes. The samples were purified using Centriflex Gel Filtration cartridges (Edge Biosystems). The samples were heated to 85°C for 2 minutes and inserted into the Prism 377 Sequencer. The sequences were analyzed using the Sequnecher™ Sequence Analysis software (Gene Codes Corp.). The sequences of the PCR product generated from human heart and human muscle were identical. The full length huE3 α I clone was obtained by ligating the two PCR products together at their XbaI site.

The nucleic acid sequence of huE3 α I (SEQ ID NO: 1), consists of an open reading frame of 5247 nucleotides which encodes a 1749 amino acid polypeptide, in addition to 695 bp in the 5' untranslated region and 362 bp in the 3' untranslated region. Alignment of the human and mouse amino acid sequence, as shown in Figure 1 (SEQ ID NOS: 2 and 15, respectively), exhibited 92.5% overall sequence identity.

In the present invention, a novel full length human E3 α cDNA (huE3 α I; SEQ ID NO: 1) was isolated and cloned and the full length polypeptide sequence (SEQ ID NO: 2) was disclosed. A partial sequence of the human E3 α gene had been previously reported. (See U.S. Patent 5,861,312; Kwon *et al.*, *Proc. Natl. Acad. of Sci. USA*, 95: 7898-7903, 1998). The reported partial sequence is encompassed in SEQ ID NO: 1; but only represents a small portion of the entire full length gene (nucleotides 702 to 1066).

EXAMPLE 2

Cloning of cDNA Encoding Human E3 α Ortholog, huE3 α II

BLAST analysis of the Amgen database (Amgen internal EST database) with the human E3 α I amino acid sequences revealed 4 Amgen EST sequences (amgi-039645, smop2-0079f12 and zhgb-aa693825 and Genebank accession no.: AA002347) which encode potential regions of the human and mouse E3 α ubiquitin ligase ortholog nucleotide sequences which are deonted as E3 α II. Based on the zhgb-aa693825 and AA002347 sequences, two PCR primer sets (#2380-88/2378-32 and #2381-48/2385-94) were designed. These sequences are set out below in Table IV.

Table IV

Primer	Sequence	SEQ ID NO:
2380-88	ATG GCG TCG CTA GAG CCA	11
2378-32	CAA AGC GGC TGA GCA TGA TCA TC	12
2381-48	TGA ACA GCC AAT CAC ACT AAG CA	13
2385-94	TTA TAA ATG CCA GTC AAT GCC AA	14

The primer sets #2380-88/2378-32 (SEQ ID NOS: 11 and 12) and #2381-48/2385-94 (SEQ ID NOS: 13 and 14) were used to generate two PCR products which encode the coding region of a novel ortholog of human E3 α ligase (huE3 α II). The 5' and 3' untranslated regions of huE3 α II were determined based on the EST sequences amgi-03645 and smop2-0079f12 in order to obtain the full length huE3 α II cDNA. PCR was performed as described above utilizing Marathon-Ready cDNA from human heart and human muscle libraries. The two PCR products were electrophoresed on a 1% gel as described by Sambrook *et al.*, *supra*. The appropriate sized bands (2.2 kB and 3.5 kB) were excised from the agarose and purified by QIAquick Gel Extraction kit (cat.# 28704). The PCR products were subcloned into the pcDNA3.1-HisA vector (Invitrogen cat.# V385-20) and transformed into *E.coli* (Strain INV α F) using the Invitrogen Original TA Cloning kit. The insert DNA was purified with the QIAprep Spin Miniprep kit (QIAGEN cat.# 27104) and subsequently digested with NotI/SacI for the 2 kB product and SacI/XhoI for the 3.3 kB product. The PCR products were sequenced as described in Example 1 and the products generated from human heart and human muscle cDNA libraries were identical. The full length huE3 α II gene was generated by ligating these two PCR products at their SacI sites.

The nucleic acid sequence of huE3 α II (SEQ ID NO: 3), consists of an open reading frame of 5265 nucleotides which encodes a 1755 amino acid polypeptide, in addition to 294 bp in the 5' untranslated region and 740 bp in the 3' untranslated region. Alignment of the human and mouse amino acid E3 α II sequences, as shown in Figure 1 (SEQ ID NOS: 4 and 6, respectively), exhibited 90.4% overall sequence identity. There is a 48.1% overall amino acid sequence identity between human E3 α I and human E3 α II (SEQ ID NOS:2 and 4, respectively).

In the present invention, a novel full length cDNA sequence encoding huE3 α II (SEQ ID NO: 3) was cloned and isolated, and the full length polypeptide sequence was disclosed (SEQ ID NO: 4). A partial sequence of huE3 α II was identified in WO9904265 as one of many partial sequences with unknown identities that were speculated to be cancer markers.

EXAMPLE 3

Cloning of the Murine E3 α II Ortholog

BLAST analysis of the Amgen internal database, Amgensis, with human E3 α II amino acid sequences identified the mouse cDNA clone (Smop2-00079-fl2) as a potential mouse ortholog of E3 α II ubiquitin ligase. The Amgen database contained the entire coding region of the mouse E3 α II ubiquitin ligase (muE3 α II) gene. The cDNA clone of was obtained from the Amgen sequencing group. The sequence of the clone was confirmed to be the full cDNA of muE3 α II as described in Example 1. The nucleic acid sequence of muE3 α II (SEQ ID NO: 5), consists of an open reading frame of 5265 nucleotides which encodes a 1755 amino acid polypeptide, in addition to 765 bp in the 5' untranslated region and 56 bp in the 3' untranslated region.

EXAMPLE 4

Human E3 α II Tissue Expression

Tissue expression patterns of huE3 α I and huE3 α II mRNA were analyzed by Northern blot analysis. To detect the presence of huE3 α II transcript in various tissues, a ³²P-labeled fragment of huE3 α II, which was 452 bp and corresponded to nucleotides 3557-4009 of SEQ ID NO: 3, was used as a probe. For detection of huE3 α I transcript in various tissues, a ³²P-labeled fragment of huE3 α I, which was 696 bp and corresponded to nucleotides 3468 -4164 of SEQ ID NO: 1, was used as a probe.

The probes were labeled by random priming method using Prime-it RMT labeling kit (Stratagene, Cat# 300392). The specific activities was 1.436×10^6 cpm/ μ l for the huE3 α II probe and 1.207×10^6 cpm/ μ l for the huE3 α I probe. Human multiple tissue poly A+ RNA blots (Clontech cat.# 7780-1) were prehybridized in Church hybridization solution (1% BSA, 7% SDS, 0.5 M sodium phosphate, pH 7.0, 1 mM EDTA) for 4 hour at 65°C. The blots are then hybridized in Church hybridization solution with 3.0×10^6 cpm/ml 32 P labeled probe for overnight at 65°C. The blots are then washed 3 times in Wash B buffer (1% SDS, 0.04 M sodium phosphate, 1 mM EDTA) for 5 minutes each at room temperature, followed by two times at 65°C. The blots were exposed to X-ray film at room temperature overnight (for huE3 α II detection) or one week (for huE3 α I detection).

The Northern blot analysis revealed that huE3 α II (Figure 2) is predominantly expressed in skeletal muscle, with moderate expression in heart and kidney tissue and minimal or no expression in other tissues examined including brain, colon, thymus, spleen, liver, small intestines, placenta, lung and peripheral white blood cells. In contrast, the expression of huE3 α I (Figure 3) is less muscle-specific. Although heart and skeletal muscle had relative high levels of huE3 α I transcripts, moderate levels of huE3 α I was found to spread through the various tissues examined. The results indicate that huE3 α II is the more muscle-specific form of huE3 α which is predominantly expressed in skeletal muscle tissue.

EXAMPLE 5

Production of huE3 α Polypeptides

A. Bacterial Expression of huE3 α Polypeptides

PCR is used to amplify template DNA sequences encoding a huE3 α polypeptide using primers corresponding to the 5' and 3' ends of the sequence. The amplified DNA products may be modified to contain restriction enzyme sites to allow for insertion into expression vectors. PCR products are gel purified and inserted into expression vectors using standard recombinant DNA methodology. An exemplary vector, such as pAMG21 (ATCC No. 98113) containing the *lux* promoter and a gene encoding kanamycin resistance is digested with BamHI and NdeI for directional cloning of inserted DNA. The ligated mixture is transformed into an *E. coli* host strain by electroporation and transformants are selected for kanamycin resistance. Plasmid DNA

from selected colonies is isolated and subjected to DNA sequencing to confirm the presence of the insert.

Transformed host cells are incubated in 2x YT medium containing 30 µg/ml kanamycin at 30°C prior to induction. Gene expression is induced by the addition of N-(3-oxohexanoyl)-dl-homoserine lactone to a final concentration of 30 ng/ml followed by incubation at either 30°C or 37°C for six hours. The expression of huE3α polypeptide is evaluated by centrifugation of the culture, resuspension and lysis of the bacterial pellets, and analysis of host cell proteins by SDS-polyacrylamide gel electrophoresis.

Inclusion bodies containing huE3α polypeptide are purified as follows. Bacterial cells are pelleted by centrifugation and resuspended in water. The cell suspension is lysed by sonication and pelleted by centrifugation at 195,000 x g for 5 to 10 minutes. The supernatant is discarded, and the pellet is washed and transferred to a homogenizer. The pellet is homogenized in 5 ml of a Percoll solution (75% liquid Percoll/0.15 M NaCl) until uniformly suspended and then diluted and centrifuged at 21,600 x g for 30 minutes. Gradient fractions containing the inclusion bodies are recovered and pooled. The isolated inclusion bodies are analyzed by SDS-PAGE. A single band on an SDS polyacrylamide gel corresponding to *E. coli*-produced huE3α polypeptide is excised from the gel, and the N-terminal amino acid sequence is determined essentially as described by Matsudaira *et al.*, *J. Biol. Chem.*, 262: 10-35 (1987).

B. Mammalian Cell Production of huE3α Polypeptides

The huE3α DNA was subcloned into a mammalian expression vector as described above using standard DNA technology. An exemplary expression vector, pCEP4 (Invitrogen, Carlsbad, CA), which contains an Epstein-Barr virus origin of replication, may be used for the expression of huE3α in 293-EBNA-1 cells. Amplified and gel purified PCR products are ligated into pCEP4 vector and lipofected into 293-EBNA cells. The transfected cells are selected in 100 µg/ml hygromycin and the resulting drug-resistant cultures are grown to confluence. The cells are then cultured in serum-free media for 72 hours. The conditioned media is removed and, huE3α protein polypeptide expression is analyzed by SDS-PAGE. Human E3α polypeptide expression may be detected by silver staining. Alternatively, huE3α polypeptide is produced as a

fusion protein with an epitope tag, such as an IgG constant domain or a FLAG epitope, which may be detected by Western blot analysis using antibodies to the tag peptide.

Human E3 α polypeptides may be excised from an SDS-polyacrylamide gel, or huE3 α fusion proteins are purified by affinity chromatography to the epitope tag, and subjected to N-terminal amino acid sequence analysis as described herein.

EXAMPLE 6

Production of Anti-huE3 α Polypeptide Antibodies

Antibodies to huE3 α polypeptides may be obtained by immunization with purified protein or with huE3 α peptides produced by biological or chemical synthesis. Suitable procedures for generating antibodies include those described in Hudson and Bay, *Practical Immunology, Second Edition*, Edition, Blackwell Scientific Publications.

In one procedure for the production of antibodies, animals (typically mice or rabbits) are injected with a huE3 α antigen (such as a recombinant truncated form of huE3 α polypeptide), and those with sufficient serum titer levels as determined by ELISA are selected for hybridoma production. Spleens of immunized animals are collected and prepared as single cell suspensions from which splenocytes are recovered. The splenocytes are fused to mouse myeloma cells (such as Sp2/0-Ag14 cells), allowed to incubate in DMEM with 200 U/ml penicillin, 200 μ g/ml streptomycin sulfate, and 4 mM glutamine, then incubated in HAT selection medium (Hypoxanthine; Aminopterin; Thymidine). After selection, the tissue culture supernatants are taken from each fusion well and tested for anti-huE3 α antibody production by ELISA.

Alternative procedures for obtaining anti-huE3 α antibodies may also be employed, such as the immunization of transgenic mice harboring human Ig loci for production of human antibodies, and the screening of synthetic antibody libraries, such as those generated by mutagenesis of an antibody variable domain.

EXAMPLE 7

Biological Activity of huE3 α polypeptides

Human E3 α family members are known to catalyze the ubiquitin conjugation reaction which ultimately results in protein degradation. To determine the biological activity of huE3 α polypeptide, the rate of ubiquitin conjugation and the

rate of protein degradation are measured. The following are examples of assays to measure these biological activities.

A. Ubiquitin Conjugation Assay:

5 The enzymatic activity of E3 α family members is thought to be the rate limiting step in ubiquitin conjugation. Rat skeletal muscles are dissected, homogenized, and centrifuged at 100,000 x g to remove proteosomes. The soluble extract is incubated with ¹²⁵I-ubiquitin (Amersham, Arlington Heights, IL) (0.15 mg/ml) in 20 mM Tris (pH 7.4), 1 mM DTT, 5 mM MgCl₂, and 2 mM ATP γ S at 37°C in the presence and absence
10 of huE3 α polypeptide. At various time points, the reactions are terminated by the addition of sample buffer and SDS-PAGE is performed on a 12% gel. The gel is then dried and autoradiographed. If huE3 α acts as an E3 α family member, the level of ubiquitination should increase in extracts treated with the huE3 α polypeptide (Soloman *et al.*, *Proc. Natl. Acad. of Sci. U.S.A.*, 95: 12602-07, 1998).

B. Protein Degradation Assays:

15 Measurement of tyrosine release is a preferred method for determining the rate of protein turnover in skeletal muscles. Rat skeletal muscles are dissected and homogenated. The extracts are incubated at 37°C for 2 hours in 20 mM Tris (pH 7.6),
20 5 mM MgCl₂, 2 mM DTT, ATP-regenerating system (10 μ g creatine phosphokinase and 10 mM creatine phosphate), 1 mM ATP, and 25 mg of ubiquitin in the presence and absence of huE3 α polypeptide. Subsequently, the reactions are terminated with 20% TCA. After centrifugation, the concentrations of tyrosine in the supernatant is measured by fluorescence spectroscopy according to the method of Waakkes and Udenfriend (*J. Lab. Clin. Med.*, 50: 733-736, 1957).
25

 Measurement of radiolabeled proteins will also indicate if huE3 α polypeptide exhibits E3 α family biological activity. Rat skeletal muscle homogenates are incubated at 37°C for 2 hours with ¹²⁵I-labeled N-end pathway substrates, such as ¹²⁵I-lysozyme and ¹²⁵I-lactalbumin, in the presence and absence of huE3 α polypeptide.

30 Following the incubation, 20% TCA is added to precipitate the radioactivity. The release of TCA-soluble radioactivity is measured using a gamma counter and correlates the rate of protein degradation. The addition of huE3 α polypeptide should increase the rate of protein degradation in both of these assays.

EXAMPLE 8

Identification of Modulators of the Biological Activity of huE3 α Polypeptides

The assays described in Example 7 demonstrate preferred methods to measure the biological activity of huE3 α as an ubiquitin ligase. These methods are also useful for identifying modulators of huE3 α ubiquitin ligase activity.

The rate limiting step of ubiquitin conjugation consists of E3 α catalyzing the transfer of the activated ubiquitin molecule to the target protein. The rate of ubiquitination modulated by huE3 α can be measured in dissected rat skeletal muscles as described in Example 7. The addition of potential huE3 α modulators (inhibitors or stimulators) to this system will allow for the identification of E3 α stimulators and inhibitors by virtue of their ability to modulate the level or rate of ubiquitin conjugation to the target protein. If the addition of the modulator decreases the rate of huE3 α -modulated ubiquitin conjugation, it is considered a huE3 α inhibitor. If the modulator increases the rate of ubiquitin conjugation it is considered a stimulator.

The effect of huE3 α modulators can also be determined by measuring their effect on the rate of protein turnover as described in Example 7. If huE3 α exhibits the biological activity of an ubiquitin ligase, it will induce protein degradation. Protein turnover is measured by quantitating tyrosine release or the degradation of radioactively labeled N-end pathway substrates in the presence of E3 α modulators. The addition of effective huE3 α modulators will either increase or decrease the rate of protein degradation.

EXAMPLE 9

Identification of huE3 α I Single Nucleotide Polymorphisms (SNP)

A BLAST search of the Celera Human Genome database was conducted using the huE3 α I cDNA sequence (SEQ ID NO: 1) as a probe. The sequences identified in the search were used to manually assemble a polynucleotide sequence (SEQ ID NO: 18) which was discovered to have a single nucleotide mismatch at nucleotide 5397 of the huE3 α I cDNA sequence (SEQ ID NO: 1). The polynucleotide sequence of SEQ ID NO: 18 contains a huE3 α I SNP with a change of a cytosine to a thymidine at position 4702, which caused the predicted amino acid sequence of SEQ ID NO: 2 to change from an Arg residue to a W (Trp) residue at position 1508.

PCR was carried out to confirm the polynucleotide sequence of huE3 α I cDNA. Primers were designed to flank the mismatch as follows: 5' AGAAGGAGAGTACAGTGCCTCTG (SEQ ID NO: 20) and 5'CGAAAGCATCCTGTCCTCTG (SEQ ID NO: 21). PCR was carried out as described in Example 1 with the Marathon-Ready cDNA library (Clontech cat no. 7413-1) from which huE3 α I cDNA was cloned. The PCR reactions resulted in 8 individual PCR products which had identical sequences to the huE3 α I SNP (SEQ ID NO: 18).

These experiments have confirmed the sequence of a huE3 α I SNP set out in SEQ ID NO: 17 wherein the nucleotide at position 4702 is a thymidine. Accordingly, the correct predicted amino acid sequence is set out as SEQ ID NO: 19, wherein the residue at position 1568 is W (Trp).

EXAMPLE 10

Human E3 α I and E3 α II Stimulate Ubiquitination

To confirm that huE3 α I and huE3 α II have the predicted enzymatic activity of stimulating ubiquitin conjugation, ubiquitination reactions were carried out in 293 cells. Cultures of 293T cells (ATCC accession no. CRL1573) were transfected with huE3 α I or huE3 α II full length cDNA (SEQ ID NOS: 1 or 3, respectively) that had been subcloned into pcDNA3.1 vector (Invitrogen) under the control of the CMV promoter using Lipofectamine reagent 2000 (Gibco, cat no. 11668-027) according to the manufacture's instructions. As a control, 293T cultures were transfected with pcDNA3.1 vector without the cDNA insert. The transfected cells were lysed in ice-cold lysis buffer (50mM Tris-HCl (pH 8.0), 2mM DTT, 5 mM MgCl₂) in the presence of Sigma P8340 protease inhibitor cocktail (containing 4-(2-aminoethyl) benzenesulfonyl fluoride, pepstatin A, E-64, bestatin, leupeptin and aprotinin) at 100 μ l/10⁷ cells. The crude lysates were then centrifuged at 10,000 g for 10 minutes.

The supernatants prepared from vector- (Control), human E3 α -I- (hu-E3 α -I) or human E3 α -II- (hu-E3 α -II) transfected cells were subjected to ubiquitination reactions. To measure ubiquitination of endogenous proteins, 30 μ g of cell lysate was incubated with ¹²⁵I-ubiquitin (0.15 mg/ml, approximately 10⁷cpm) in a total volume of 40 μ l in a buffer containing 50 mM Tris, pH 8.0, 2 mM DTT, 5 mM MgCl₂, 2 mM adenosine 5'-[γ -thio]triphosphate (ATP S), 50 μ g/ml ubiquitin

aldehyde, MG132 20 µg/ml and protease inhibitor cocktail (Sigma P8340) at 37°C for 30 minutes. Reactions were stopped by adding sample buffer and were subjected to 12% SDS PAGE. The gels were then dried and autoradiographed.

The ubiquitination of α-lactalbumin, a known substrate for N-end Rule Ubiquitination was also measured with the 239T transfected cells. For these reactions, 30 µg of cell lysate proteins was incubated with 0.15 mg/ml ¹²⁵I-α-Lactalbumin and 0.25 mg/ml unlabeled ubiquitin in a total volume of 40 µl in a buffer containing 50 mM Tris (pH 8.0) 2 mM DTT, 5 mM MgCl₂, 2 mM adenosine 5'-[thio]triphosphate (ATP S), ubiquitin aldehyde 50 µg/ml, 20 µg/ml MG132 and protease inhibitor cocktail (Sigma P8340) at 37°C for 30 minutes. Reactions were stopped by adding sample buffer and each reaction was run of a 8% SDS PAGE was performed. The gels were then dried and autoradiographed

The amount of radioactivity incorporated into high molecular weight bands denoted as "ubiquitin-protein conjugates" in Figure 4 (above 18 kDa for endogenous proteins and above 35 kDa for α-Lactalbumin) were quantitated by using PhosphorImager and plotted (right panel). These reactions indicated that recombinant expression of huE3αI or huE3αII in 293 cells lead to accelerated ubiquitination of endogenous cellular proteins and ubiquitin conjugation to α-lactobumin, a bona fide N-end rule substrate.

To further substantiate the enzymatic activity of huE3αI and huE3αII, ubiquitin conjugation to endogenous cellular proteins were measured in cultured muscle cell lines. Cultures of murine C₂C₁₂ or rat L6 myotube cells (ATCC accession nos. CRL-1772 and CRL-1458, respectively) were transfected with huE3αI or huE3αII full length cDNA under control of the CMV promoter using Lipofectamine 2000 Reagent (Gibco). Mock transfection with the pcDNA3.1 vector without a cDNA insert was performed as a control. Cell lysates were prepared as described above for the 293T cells and the resulting supernatants were used in ubiquitin conjugation reactions. For each reaction, 30 µg of C₂C₁₂ or L6 myotube cell lysate was incubated with ¹²⁵I-ubiquitin (0.15 mg/ml, approximately x10⁷cpm) in a total volume of 25-30 µl in a buffer containing 50 mM Tris, pH 8.0, 2 mM DTT, 5 mM MgCl₂, 2 mM adenosine 5'-[thio]triphosphate (ATP S), 50 µg/ml ubiquitin aldehyde, 20 µg/ml MG132 and protease inhibitor cocktail (Sigma P8340) at 37°C for 30 minutes. Reactions were stopped by adding sample buffer and were subjected to 12% SDS PAGE. The gels were then dried and autoradiographed.

The amount of ubiquitinated muscle proteins (^{125}I -Ubiquitin protein conjugates) were quantitated as the total radioactivity incorporated into high molecular weight bands (above 18 kDa) using a Phosphorimager as shown in Figure 5 (left panel). These reactions indicated that transfection of huE3 α I and huE3 α II increased ubiquitination of cellular proteins 2-3 fold (see Figure 5, right panel) in murine C₂C₁₂ and rat myotube cultures.

EXAMPLE 11

Expression of Human E3 α I and Human E3 α II is Unregulated During Cachexia Disease States

The Yoshida Hepatoma-130 (YAH) cachexia rat model as described in Baracos *et al.* (*Am. J. Physiol.*, 268(5 Pt 1): E996-1006, 1995) was used to determine if huE3 α I and huE3 α II are upregulated in cachexia disease states. For tumor implantation, female Sprague-Dawley rats of the Buffalo strain from a colony maintained at the University of Alberta were used as the host for the YAH tumor cells. Tumor cell stocks were maintained in liquid nitrogen and used after two passages in recipient female animals of the same strain. Rats were housed in individual wire mesh cages in a temperature (24°C)- and humidity (80%)-controlled room on a 12:12-h light-dark cycle. Rats were fed ground laboratory chow (Continental Grain, Chicago, IL) containing 24% crude protein.

Rats were allocated by initial body weight to three groups such that the sizes (mean \pm SE) of the animals receiving each treatment were similar (~ 200g). Two different treatments were compared: YAH-bearing and pair-fed control rats. The pair-fed rats, which received one meal per every day at 9.00am, were fed on the basis of their body weights, the same amount of food consumed by the tumor-bearing rats. On days 1,2,3,4 and 5 after tumor-implantation, food intake was determined in preliminary experiments to be 9, 7.5, 5.3, 1.5, and 0.9% respectively, of initial body weight per day. Rats were implanted with 100 ml of ascites fluid containing YAH cells from a single donor animal. The control rats were implanted with an equal volume of saline buffer. Rats were sacrificed by CO₂ asphyxiation after 3 and 5 days, and epitrochlearis, EDL, soleus, medial gastrocnemius muscles were rapidly dissected and the gastrocnemius muscles were weighed. Tissues were frozen immediately in liquid nitrogen and stored at -70°C until use.

The gastrocnemius skeletal muscle weights in YAH-130 tumor bearing rats were significantly lower than those measured from the pair-fed control rats. As indicated in the Table V below, the YAH-130 tumor bearing rats underwent muscle wasting by day 3 after tumor implantation which was more apparent at day 5 after implantation. The muscle weights are calculated (in grams) as the mean \pm standard error.

Days after Tumor Implantation	n	Pair Fed Control (in grams)	Tumor-Bearing (in grams)	Percent Change
3 days	8	530 \pm 14.6	508 \pm 7.3	-4.3%
5 days	8	593 \pm 8.1	443 \pm 9.4	-25.3%

n = number of animals

The rate of ubiquitin conjugation of the endogenous muscle proteins were carried out as described in Example 10 using the skeletal muscles from the YAH tumor-bearing rats. The frozen gastrocnemius muscles collected (via dissection at sacrifice) from 6 tumor-bearing rats were combined. The muscle extracts (20% weight/volume) were prepared by homogenizing the muscles in a buffer containing 50 mM Tris HCl (pH 8.00), 5 mM MgCl₂, 2 mM DTT, protease inhibitor cocktail (Sigma P8340) and 10% glycerol. The homogenates were then centrifuged at 40,000g for 1 hr and the resulting supernatants were used as crude muscle extracts.

For some assays, the crude muscle extracts were fractionated further by chromatography on DEAE-cellulose (Whatman, Clifton, New Jersey) to remove endogenous ubiquitin as described by Solomon *et al.* (*Proc. natl. Acad. Sci. U.S.A.*, 95: 12602-7, 1998). The bound material Fraction II, which contained most of the ubiquitin conjugating enzymes were eluted with 50 mM Tris, pH 8.0 containing 0.5M NaCl and 1 mM DTT. Both crude extracts and Fraction II were dialyzed prior to use for ubiquitination assay against buffer containing 20 mM Tris, pH 8.0, 2 mM DTT, 5 mM MgCl₂, and 10% glycerol and stored at 70 °C until use. Crude muscle extracts were used for ubiquitin conjugation to 125I- α -lactalbumin. Fraction II was used when rates of endogenous skeletal muscles proteins were compared and also when effects of E3 α inhibitors on skeletal muscle protein ubiquitination were tested.

The Fraction II from both tumor-bearing and pair-fed control rats were subjected to ubiquitination reactions of the endogenous muscle proteins as described in

Example 10 in the presence of 20 $\mu\text{g/ml}$ of bestatin and 10 mM of either the E3 α selective inhibitor arginine methyl ester (Arg-ME) or the control alanine methyl ester (Ala-ME) (Sigma Chemicals, St. Louis MO). The reactions were incubated at 37°C for 20 minutes and the ^{125}I -Ubiquitin conjugates were resolved by 12% SDS PAGE as described in Example 10.

As shown in Figure 6, the tumor-bearing rats exhibited accelerated muscle protein ubiquitination. The increase in ubiquitination within the rat skeletal muscles of the tumor-bearing rats was attributable to the activation of the E3 α /N-end rule pathway, since the addition of E3 α specific inhibitor arginine methylester virtually abolished the accelerated ubiquitination activity (see lanes 9 and 10 on Figure 6).

To further establish the role of huE3 α I and huE3 α II in the N-end rule pathway in muscle wasting in the rat cachexia model, the rates of ubiquitination of N-end rule substrate α -lactalbumin was measured in skeletal muscle extracts from control and tumor-bearing mice. ^{125}I - α -lactalbumin (0.15 mg/ml) was incubated with crude skeletal muscle extracts (2 mg/ml) in the presence of 0.25 mg/ml of ubiquitin at 37°C for 0 or 20 minutes as described in Example 10. As shown in Figure 7, the atrophying muscles dissected from the tumor-bearing rats exhibited increased ubiquitin conjugation to ^{125}I - α -lactalbumin.

Northern blot analysis was carried out to measure the huE3 α I and huE3 α II mRNA expression in the gastrocnemius muscles of YAH-130 tumor-bearing mice. RNA from the dissected muscles was isolated with Trizol Reagent (Gibco, cat: 15596-018). The final RNA pellets were resuspended in DEPC- H_2O and 20 μg of total RNA per lane were separated by electrophoresis through 1% agarose gels. The separated RNA was transferred to nylon membranes and cross-linked to the filter by exposure to ultraviolet light.

The cDNA probes were generated by PCR with the following primers: for Hu-E3 α -I probe: 5' primer, AGG AAG CTG TGG TCA TGT (SEQ ID NO: 22); 3' primer, GTT AGG AAG AAC AAC TG (SEQ ID NO: 23); for Hu-E3 α -II probe: CTA AAG AAC AGC GAA GGC AAC AG (SEQ ID NO: 24); 3' primer, CGC AGC TAC CCC AAC ACA TTA T (SEQ ID NO: 25). PCR was carried out for 30 cycles at 94°C for 45 seconds, 50-58 °C for 45 seconds, and 72°C for 1 minutes using a commercially available kit (Boehringer Mannheim, cat: 1578553,). The PCR product was cloned into the pCR2.1 vector using the Original TA Cloning kit (Invitrogen). After digestion with EcoRI, the cloned PCR product was sequenced and confirmed.

The resulting cDNA probes were radiolabeled with [³²P]dCTP using the Prime-it RMT labeling kit (Stratagene, cat: 300392). Membranes were prehybridized and hybridized (with the cDNA probes) in buffer containing 1% BSA, 7% SDS, 0.5 M Sodium Phosphate (pH 7.0), 1mM EDTA. Subsequently, the blots were washed in buffer containing 1% SDS, 0.04 M Sodium Phosphate, 1 M EDTA, by the method of Church and Gilbert (*Proc. Natl. Acad. Sci. U.S.A.* 81:1991-1995, 1984) and exposed to radiographic film at -70°C overnight.

As shown in Figure 8, the expression of huE3αII mRNA was increased at day 3 post-tumor implantation (see left panel) but the level of huE3αI had not changed significantly at day 3 (see right panel). This coincides with the time point when the significant decrease in muscle mass was detectable in the C26 tumor-bearing mice (See Table VI in Example 12). The expression of both huE3αI and huE3αII was elevated at day 5 post-tumor implantation in the tumor bearing rats. This corresponds to a cachexia state with severe muscle wasting.

EXAMPLE 12

Expression of Human E3αI and Human E3αII in a Murine Cancer Cachexia Model of C26 Tumor Bearing Mice

The Colon-26 (C-26) tumor model of cachexia was used to demonstrate the role of huE3αI and huE3αII as described in Matsumoto *et al.*, *Brit. J. Can.* 79: 764-9 (1999) and Tanaka *et al.*, *Can. Res.*, 50: 2290-5 (1990). Seventy-two week old male CDF1 mice were injected in the left flank with 0.2 ml containing either 0.5 x 10⁶ C26 cells or PBS. Following injection, body weight and food intake was observed daily. The pair fed control mice (generated as described in Example 11) were fed the daily average food intake of the tumor bearing group. On the day 12 or 17 post-injection, tumor bearing mice and pair fed control mice were sacrificed by CO₂ asphyxiation. Subsequently, a terminal serum sample was collected and the kidney, heart and gastrocnemius muscles were rapidly dissected and weighed. The resulting C26 tumors were also weighed. The tissues were frozen on dry ice and stored at -70°C.

The wet weight of the skeletal muscles from the tumor-bearing mice were significantly less than the weight of those from the pair-fed control mice as shown below in Table VI:

Days after Tumor Implantation	n	Pair Fed Control (in grams)	Tumor-Bearing (in grams)	Percent Change
12 days	12	0.127 ± 0.007	0.116 ± 0.0072	-8.6%
17 days	12	0.117 ± 0.009	0.087 ± 0.001	-26%

n = number of animals

RNA was isolated at day 12 and day 17 from the gastrocnemius muscle and cardiac muscle from the C26 tumor-bearing and pair-fed control mice as described in Example 11. Northern blot analysis was carried out by loading 20 µg of total RNA per lane and separating by electrophoresis through 1% agarose gels. The separated RNA was transferred to nylon membranes and cross-linked to the filter by exposure to ultraviolet light.

The cDNA probes were generated by PCR with the following primers: for mouse E3α-I probe: 5' primer, TTT CTT CCA TTC CCT GCA TAC A (SEQ ID NO: 26), 3' primer, CAA AAC TTT ATA AAG GTG CCC GTA A (SEQ ID NO: 27), and for Mouse E3α-II probe: 5' primer, ATT CCC TGC ATG CAC TTC AGT AA (SEQ ID NO: 28), 3' primer, CAT TCC CTG CAT GCA CTT CAG (SEQ ID NO: 29). PCR was carried out for 30 cycles at 94°C for 45 seconds, 50-58 °C for 45 seconds, and 72°C for 1 minutes using a commercially available kit (Boehringer Mannheim cat: 1578553,). The PCR product was cloned into the pCR2.1 vector using the Original TA Cloning kit (Invitrogen). After digestion with EcoRI, the cloned PCR product was sequenced and confirmed.

The resulting cDNA probes were radiolabeled with [³²P]dCTP using the Prime-it RMT labeling kit (Stratagene, cat: 300392). Membranes were prehybridized and hybridized (with the cDNA probes) in buffer containing 1% BSA, 7% SDS, 0.5 M Sodium Phosphate (pH 7.0), 1mM EDTA. Subsequently, the blots were washed in buffer containing 1% SDS, 0.04 M Sodium Phosphate, 1 M EDTA, by the method of Church and Gilbert (*Proc. Natl. Acad. Sci. U.S.A.* 81:1991-1995, 1984) and exposed to radiographic film at -70°C overnight.

As shown in Figure 9, at day 12 after tumor-implantation there was a clear increase in huE3αII mRNA expression in the skeletal muscles of tumor-bearing mice. Expression of both huE3αI and huE3αII was increased at day 17 post-implantation. Increased expression of huE3αII mRNA coincides with the time point

when the significant decrease in muscle mass became detectable in tumor-bearing mice (See Table VI above). The expression of huE3 α I and huE3 α II remained unchanged in the cardiac muscle of the tumor-bearing mice. This corresponds to a cachexia state with severe muscle wasting.

5 The data described in both Examples 11 and 12 show that in experimental cachexia models, there was a sharp rise in the rate of ubiquitination in skeletal muscle tissues. The accelerated ubiquitination is due largely to the activation of E3 α , since addition of the E3 α -selective inhibitor, arginine methylester, virtually abolished all the increased ubiquitination activities. In addition, the data
10 demonstrated that in two widely used experimental models of cachexia (murine C26 tumor-bearing model and rat YAH-130 tumor-bearing model), the mRNA levels of E3 α -I and E3 α -II increase significantly and specifically within skeletal muscle during the course of cachexia and muscle wasting. In these disease models and during the course of cachexia, the induction of E3 α -II occurred earlier than that of E3 α -I and
15 coincided with the early onset of muscle wasting. During the late stage of cachexia, both E3 α -I and E3 α -II were markedly induced when muscle wasting became pronounced. Therefore, the results suggest that E3 α -II may play a more critical role in cachexia, although both E3 α -I and E3 α -II are apparently involved in the disease process.

20 EXAMPLE 13

Treatment of Muscle Cells with TNF α and IL-6 leads to Increased Expression of Human E3 α II and Increased Ubiquitination

25 Treatment with the proinflammatory cytokines, TNF α and IL-6, caused the induction of huE3 α II in C₂C₁₂ myotube cultures. C₂C₁₂ myoblasts were cultured in 100-mm dishes in an atmosphere of 5% CO₂ at 37°C in DMEM supplemented with 10% FBS and L-glutamine to reach 100% confluence. Myoblast differentiation was induced with DMEM supplemented with 2% horse serum and L-glutamine for 96 hours. Differentiated myotubes were then treated with TNF α (10
30 ng/ml; R&D Systems cat no. 210-TA) or IL-6 (10 ng/ml; R&D Systems cat no. 206-IL) for 3 days and 5 days.

 After the 3 or 5 day incubation, RNA from differentiated C₂C₁₂ cultures was isolated with Trizol Reagent and Northern blot analysis was carried out

as described in Example 11. Isolated RNA from untreated C₂C₁₂ cultures were used as a control. The blots were hybridized with a ³²P-labeled cDNA probes specific for muE3αI (lower panels) and muE3αII (upper panels). The probes were generated as described in Example 12.

5 As shown in Figure 10, the expression of muE3αII was markedly increased in the cells treated with TNFα or IL-6 (See upper panels). Conversely, the expression of muE3αI was not drastically induced in response to proinflammatory cytokine treatment. This data indicates a role for E3αII in cytokine-mediated protein catabolism and muscle wasting.

10 Cytokine treatment also resulted in accelerated ubiquitination in differentiated C₂C₁₂ cells. C₂C₁₂ cells were differentiated for 5 days to allow formation of myotubes. The differentiated myotubes were treated with 2 ng/ml of IL-6 for 5, 24 or 48 hours. After the incubation, the cells were lysed and ¹²⁵I-Ubiquitin conjugation was carried out as described in Example 10. As shown in Figure 11, IL-6
15 treatment resulted in a marked increase in ubiquitination of cellular proteins (left panel) which was detectable 5 hours post-treatment. The increase in ubiquitination was time dependent (see right panel).

Differentiated C₂C₁₂ myotubes were also treated with increasing concentrations of TNFα (0, 3, 6, 10, 20 ng/ml) for one hour. This treatment resulted
20 in a dose dependent increase in ¹²⁵I- ubiquitin conjugation of cellular proteins as shown in Figure 12.

TNFα and IL-6 are major proinflammatory cytokines known to be involved in cachexia and tissue wasting. The data reveals that these cytokines significantly upregulate the mRNA expression of E3αII in muscle cells and stimulate
25 muscle protein ubiquitination. Proinflammatory cytokines, such as TNFα, IL-6, IL-1, interferon-gamma, CNTF and leptin, have been shown to be involved in disease states of cachexia and protein/tissue wasting, including cancer cachexia, renal cachexia (energy-protein malnutrition), burn cachexia and AIDS wasting. These findings that TNFα and IL-6 induce the expression of E3αII (Figure 9) and stimulate
30 protein ubiquitination in muscle cells (Figures 10 and 11) strongly suggest that E3αII is critical target via which various cachectic factors induce protein catabolism and cachexia/muscle wasting. This argument is further supported by our finding that

recombinant expression of E3 α II by cDNA transfection leads to marked protein ubiquitination in myotube cultures (Figure 5).

While the present invention has been described in terms of the preferred embodiments, it is understood that variations and modifications will occur to those skilled in the art. Therefore, it is intended that the appended claims cover all such equivalent variations which come within the scope of the invention as claimed.

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